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A DIGEST OF INFORMATION ON TOXAPHENE

By

R. C. Roark

Division of Insecticide Investigations

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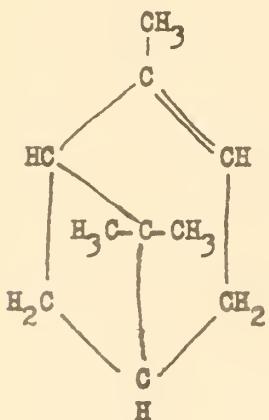
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The Interdepartmental Committee on Pest Control announced on January 17, 1949, that the word toxaphene had been accepted as a coined common name for the insecticidal chemical referred to as chlorinated camphene having a chlorine content of 67-69 percent. The term toxaphene applies to the technical chemical produced and meeting the standard described above. Acceptance of the word toxaphene as a coined name for this insecticidal chemical became possible as a result of action taken by the Hercules Powder Company to surrender the trade-mark name Toxaphene.

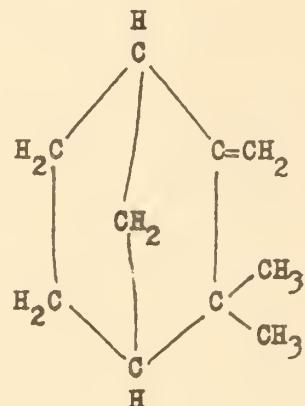
CHEMISTRY OF TOXAPHENE

Toxaphene is a yellow waxy solid with a mild piney odor; it melts in the range of 65° to 90° C.; its density is 1.6 g./cc.; it is insoluble in water but readily soluble in organic solvents. For example its solubility in refined kerosene is over 280 grams per 100 ml. at 27° C. Technical grade DDT has a solubility in this solvent of only 4 grams per 100 ml.

Toxaphene is made by chlorinating camphene to a chlorine content of from 67 to 69 percent which results in a material having the approximate empirical formula $C_{10}H_{10}Cl_8$. Camphene is made by isomerizing alpha-pinene, a major constituent of turpentine. The structural formulas of pinene and camphene are shown below:



alpha-pinene, $C_{10}H_{12}$



camphene, $C_{10}H_{12}$

It is apparent from the structural formula of camphene that when chlorine is added to it the reaction may be substitution, addition, rearrangement, or a combination of these. It is not surprising, therefore, that the structural formula of toxaphene is not known.

Like DDT toxaphene slowly splits off HCl upon heating, the rate depending upon temperature and the presence of impurities such as certain iron compounds that catalyse the dehydrochlorination. Holding toxaphene for 24 hours at temperatures from 100° to 155° C. causes a slight loss of HCl. When exposed to ultraviolet light toxaphene splits off HCl faster than does DDT under the same conditions. In the absence of moisture a 5-percent toxaphene solution in kerosene did not attack commonly used container materials, but a 50-percent water miscible concentrate corroded all metals except black iron coated with a special lacquer.--Parker and Beacher (231).

Analysis

There is no specific qualitative or quantitative chemical test for toxaphene. The total chlorine content of toxaphene may be determined by

refluxing an isopropanol solution of it with metallic sodium and titrating the chloride formed as is done with DDT and other chlorinated insecticides. The factor used in the laboratories of the Division of Insecticide Investigations of the Bureau of Entomology and Plant Quarantine to convert total chlorine to toxaphene is 1.46. This factor is based on a chlorine content of 68.54 percent in toxaphene, the theoretical amount demanded by the formula $C_{10}H_{10}Cl_8$.

Ard (11) has observed that when 100 mg. of toxaphene is refluxed with 25 ml. of isopropyl alcohol and 2.5 grams of sodium, a perceptible graying develops, also a strong odor of crude methylnaphthalenes. Chlordane gives similar reactions.

FORMULATIONS

Toxaphene is sold for insecticide use in the form of solutions, dusts, wettable powders and emulsions. These are made in the same way that corresponding chlordane formulations are made.

Mail (193) has pointed out that the extreme solubility of toxaphene in a wide variety of solvents makes emulsification a relatively easy matter. Many of the emulsifiers that work well with chlordane give good results with toxaphene when formulated in the same proportions, but finished emulsions may not have the same appearance or physical properties.

Frear *et al.* (95) have compiled a list of trade-marked insecticides, including those that contain toxaphene. The name of the manufacturer and the composition and use of each of these is given.

The Arizona Agricultural Experiment Station (12) has published a list of 1004 economic poisons registered in that state by 101 registrants and presents the results of analysis of 4 toxaphene formulations.

The kind of formulation affects the amount of toxaphene residue remaining on various plants. Data on alfalfa have been published by Leakso and Johnson (173). All samples for these analyses were taken within 24 hours after application. Every precaution was taken to minimize the loss of toxaphene from the foliage through handling.

Deposition of toxaphene on alfalfa

Formulation	Rate of application lb./acre	Average deposition Percent
Water emulsion	1-4	29
Wettable powder	2	24
Oil solution	2	14
Dust	1.5-2	7

The water emulsion consisted of 1 pound of technical toxaphene, 1/4 gallon of kerosene, 25 ml. of extra high concentrate of Igepal (a polymerized ethylene oxide condensation product) and water to make 8 gallons; the wettable powder contained 25 percent of toxaphene; the oil solution consisted of 1 pound of technical toxaphene in 2 gallons of kerosene; the dust contained 10 percent of toxaphene. The oil solution of toxaphene gave the most persistent residues. On the Bozeman, Montana, plots, losses of toxaphene up to 72.9 percent 31 days after application were noted for the water-emulsion type of formulation. The rate of loss of toxaphene was greatly decreased after the alfalfa had been baled and stored.

COMPATIBILITY

Tables and charts showing the compatibility of toxaphene with the common spray materials have been published anonymously in the American Fruit Grower (1, 4) and by Frear (94), whose table is as follows:

<u>Toxaphene mixed with:</u>	<u>Compatibility</u>	
Lead arsenate	fully compatible	
Calcium arsenate	compatibility questionable	
Paris green	fully compatible	
Cryolite	"	"
Rotenone	"	"
Pyrethrum	"	"
Nicotine	"	"
DDT	"	"
Chlordane	"	"
Benzene hexachloride	"	"
Tetraethyl pyrophosphate	"	"
Parathion	"	"
Summer oils	"	"
Dormant oils	"	"
Dinitro compounds	"	"
Lime sulfur	compatibility questionable	
Wettable sulfur	fully compatible	
Lime	compatibility questionable	
Fixed coppers	fully compatible	
Bordeaux	compatibility questionable	
Dithiocarbamates	fully compatible	

Glyoxalidines are listed as doubtfully compatible with toxaphene by the American Fruit Grower (4). Zinc sulfate plus lime also is considered to have doubtful compatibility with toxaphene (4) but Griffiths and King (123) consider the combination to be compatible. Ewing and Parencia (82) reported that toxaphene appears to be compatible with parathion.

Weather factors in spraying and dusting pome fruits and stone fruits with toxaphene are considered by an anonymous writer in the American Fruit Grower (3, 5). Toxaphene is represented in a chart as safe to use on apples, pears, and stone fruits under five weather conditions: temperature above 85°, temperature 85° to 65°, temperature 65° to 40°, light rain; and high humidity with slow drying.

FREIGHT CLASSIFICATION

Beginning June 1, 1948, toxaphene was shipped under a new item—"Polychlor agricultural insecticides and fungicides" in the consolidated freight classification. Polychlor is a name selected by the Classification Committee for a group of compounds, including DDT, benzene hexachloride, toxaphene and chlordane, which contain three or more chlorine atoms. This name is used only for shipping purposes, not for labeling. It was selected to avoid confusion among carriers as well as shippers over the long chemical names of this group of products, whose importance is increasing, and to avoid numerous requests for exceptions for individual products. All items in this group now will enjoy the same freight classification in their territory. Shippers should note that this new item does not cover the technical chemicals which should still be described as "chemicals, noibn"; likewise it does not cover liquid preparations, or dry formulations in excess of 50 percent of the chlorinated chemical. Such formulations will continue to be described as "insecticides or fungicides, noibn."--Anon. (2).

EFFECT ON PLANTS

When added to the soil

At Beltsville, Md., the effect of toxaphene on plants was tested under greenhouse conditions in Chester clay loam, Sassafras sandy loam, Evesboro fine sand and muck. Toxaphene depressed plant growth when applied to the soil at relatively low levels without causing any obvious symptoms. Soil type and character, especially the quantity of organic material or colloidal clay present are important factors in determining the toxicity of organic insecticides. The toxicity to plants of toxaphene added to the soil appears to decrease with time. This compound is evidently destroyed by soil fungi or bacteria.--Cullinan (52, 53).

When added to greenhouse soil toxaphene stimulated the development of the bacteria and fungi, with and without cottonseed meal; evidently these organisms were using it for food.--Smith and Wenzel (275).

Toxaphene appears to be decomposed in the soil and rendered nontoxic after several months.--Foster (92).

Toxaphene 5-percent dust was added to soil at the rate of 27.5 pounds of toxicant per acre, equivalent to 1.01 pounds per 1,000 cubic feet. Twenty-nine different vegetables planted in this treated soil showed no evidence of plant injury.--Morrison *et al.* (206).

In preliminary tests in South Carolina in Grady sandy loam, a moderately heavy soil, 36-percent toxaphene applied to the soil at rates as high as 2,000 pounds per acre at the time of seeding caused no apparent injurious effects to any of nineteen crops.--Watts (310).

When applied directly to plants

Toxaphene sprays were applied to 52 species of trees and shrubs and to 19 species of evergreens commonly present in ornamental plantings. It was tested for phytotoxicity, on tender new growth in the spring (Connecticut) and under mid-summer conditions of high temperature and high humidity (Delaware), at 0.5, 1, 2, and 4 pounds per 100 gallons of water. It proved completely safe at these rates on all species, except two - Imperial Gage plum and sugar maple.--Stearns *et al.* (282).

A 25-percent wettable toxaphene at 2 pounds per 100 gallons caused no injury when applied on apples, grapes, peaches, and on string and lima beans, but produced severe chlorosis followed by necrosis on cucumbers and on cantaloupes and a slight yellowing of the terminal growth on potatoes. The 50-percent water-dispersible formulation at the rate of 1 pound per 100 gallons, although apparently safe on apples, grapes, and peaches, produced severe chlorosis on potatoes. When used as a dust, no difficulties were experienced on string and lima beans; cucumbers, cantaloupes, and squash, however, were adversely affected.--Stearns *et al.* (281).

Results of phytotoxicity tests indicate that 25-percent wettable powder and 32-percent water miscible and 50-percent water dispersible formulations of this compound are safe on potatoes at the concentration of 1 pound per 100 gallons of water.--Parker *et al.* (233).

Toxaphene spray, prepared from an emulsion to give 0.5 pound per 100 gallons of water appeared to be safe to use on Kalanchoe globulifera coccinea (referable botanically to Kalanchoe blossfeldiana).--Lumsden and Smith (185).

Toxaphene practically destroyed a crop of cucumbers and squash in Florida.--Kelsheimer (155).

Additional observations of the effect of toxaphene on plants have been recorded as follows: No injurious effect on tobacco (66, 323), beans (231), clover (166), cabbage, cauliflower and broccoli (62, 63); caused temporary chlorosis of potato terminal leaflets (231); injured potato plants (35, 296) and decreased yield of tubers (296); caused potato foliage to be greener and increased yield of tubers (205); produced an off-flavor in potatoes (120, 122); burned pear leaves when applied with or following mineral oil (37); no injury to pear fruit or foliage (127, 128); no injury to peach fruit, foliage, wood, or buds (60, 277); did not adversely affect the flavor of fresh or canned peaches (269); injured peach leaves but wettable sulfur prevented this injury (80, 268); caused noticeable injury to peach fruit and foliage (115); no injury to sugar-cane foliage (147); decreased yield of cane (70); severely burned concord grape foliage (48); injured cucurbits (38, 90, 231) except the variety Umatilla Marblehead in eastern Oregon (49).

Effect on germination

Toxaphene at 5, 15, or 30 pounds per acre (mixed with an 0-12-16 celery fertilizer) had no effect on the germination of cabbage, pepper tomato and bean seeds and did not give an undesirable taste to the cabbage.--Hayslip (135).

EFFECT ON ANIMALS

Earthworm

Toxaphene as a 25-percent wettable powder, 1 pound of toxicant per 100 gallons of water, reduced the earthworm population of the fairway of a Florida golf course but the control was not considered satisfactory.--Hayslip (135).

Fish

Laboratory tests made by the Fish and Wildlife Service at Leetown, West Virginia showed that toxaphene is considerably more toxic to fishes than is DDT and is lethal to silverling minnows, spotfin shiners, creek chubs, fallfish, and black-nosed dace in concentrations of less than 0.04 ppm. In outdoor ponds an application of 0.125 pound to an acre (0.22 ppm.) killed all these species, but goldfish survived. Repeated tests on bluegill, sunfish and young rainbow and brown trout indicated that bluegills were less sensitive than trout, which were killed even at concentrations of 0.005 ppm. (one part in 200,000,000). The threshold limit for bluegills was 0.01 ppm.--Linduska and Surber (180).

The U. S. Public Health Service tested the effect of toxaphene on 32 species of fish in ponds and found it to be very toxic, giving complete kills at 0.2 and 0.1 pound per acre after two and three applications in deep ponds. Kills were obtained at dosages of less than 1 part in 27 million, indicating that this material is as toxic or more toxic to fish than rotenone and may be useful as a substitute for it in fish management work.--Tarzwell (288).

In Alaska, experiments with toxaphene in running water indicated strong toxicity, but not to the degree that the still water work did. Toxaphene in xylene emulsion produced substantial mortalities with salmon and trout after 15-minute exposure periods at all strengths over 3 ppm. in streams and over 5 ppm. in troughs. When toxaphene was tested in acetone suspensions, kills were noted above strengths of 5 ppm. Fuel oil solutions and Velsicol solutions were tested at strengths of 2 ppm. and below, causing no significant lethal effects. In the stream work done in Alaska in 1947, it was found that the dominant fish food items, the caddice larvae, were more resistant to every insecticide tested than were the trout and salmon. These insecticides were DDT, BHC, toxaphene, and chlordane and were applied as emulsions, acetone suspensions, and, in some cases, as fuel oil solutions and Velsicol solutions.--Cope (44).

In Alaska toxaphene was toxic to rainbow trout at 0.5 to 5 ppm. depending on the formulation.--Gjullin et al (112).

Birds

In 1948 the Wyoming Game and Fish Commission determined the LD-50 of toxaphene to the chukar partridge, the pheasant and the sage grouse to be 50, 200 and 90 milligrams per kilogram of body weight. It was calculated that to obtain this dose a chukar partridge must eat 285 grams, a pheasant 2,890 grams and a sage grouse 1,160 grams of grasshoppers containing 100 ppm. of toxaphene. The danger of toxaphene broadcast for grasshopper control to game birds and other forms of wildlife is pointed out.--Post (238).

Mammals

Toxaphene was dissolved in cottonseed oil and this solution in a gelatin capsule fed to dogs that had been starved for 24 hours. The smallest dose of toxaphene given was a total of .636 grams of 25 percent active ingredients or 20 mgm./kgm. This did not produce death but did cause convulsions. Because of the high toxicity of toxaphene it is not recommended that this insecticide be used on dogs.--Batte and Turk (16).

At Kerrville, Texas, toxaphene emulsions and suspension of wettable powder were applied as sprays and dips containing 1.5 percent of the technical material to cattle, sheep, goats, hogs, and horses. Two series of tests were made, the treatments being applied eight times at 4-day intervals. In addition to these tests, toxaphene has been widely used, sometimes at high concentrations, in field work, and no apparent injury has been noted.--Bushland et al. (31).

In California samples of vegetation taken 8 to 15 days after treatment with toxaphene at rates from 0.5 to 2.0 pounds per acre contained 6 to 70 ppm. Dairy cows were allowed to graze on Ladino clover known to carry an average of 22 ppm. of organic chlorine. This amount was the average residue on half-acre plots, covering an entire field, treated with chlordane, toxaphene, TDE, BHC, and DDT. No ill effects on the dairy cows were observed or reported.--Wilson (320).

In Montana 14 yearling steers and 14 ewe lambs were divided into 7 lots of 2 steers and 2 lambs each. Six of these lots were individually fed alfalfa hay which had been treated with toxaphene at different rates, varying from 1 pound per acre to 8 pounds per acre. One lot used as a control received untreated alfalfa hay. None of the animals showed any toxic effect except the two steers receiving hay treated with 8 pounds toxaphene per acre. These steers developed temporary nervous symptoms, but recovery was rapid and complete.--Marsh (194).

Mature sheep, goats, cattle, horses, and swine showed no harmful effects from eight external applications of 1.5 percent toxaphene at 4-day intervals. Young calves were more susceptible than mature animals. One- to two-month-old calves showed toxic symptoms after a single spraying with 1.5 percent toxaphene emulsion containing xylene or kerosene or wettable powder. Single or repeated treatments with 0.75 percent concentration had no harmful effect on calves.--U. S. Bur. Animal Indus. (297).

Toxaphene in animal tissues

Fatty tissues from animals fed four months on alfalfa hay which had been sprayed twice with toxaphene at the rate of 1 and 2 pounds per acre (1.5 pounds per acre is the spray application rate recommended by the United States Department of Agriculture in 1948 and 1949 for grasshopper control) showed toxaphene concentrations of about 25 and 300 ppm., respectively. The concentrations of toxaphene in the commercial meat cuts from these same animals were relatively low, the rib roasts giving an analysis of less than 1 ppm. and 7 ppm., respectively. Fatty tissue of the steer fed hay which had received two applications of 4 pounds per acre (more than 2.5 times the recommended rate) contained about 700 ppm., while lean meat from the same steer gave an analysis of 35 ppm. Biopsy fat samples taken from steers at 11, 19, and 23 weeks after termination of feeding treated hay showed that most of the toxaphene had been eliminated by the eleventh week. By the nineteenth week there was no significant difference in organic chlorine content of biopsy samples from control animals and those fed treated hay. The results with sheep were generally similar to those with steers but the distribution of toxaphene within the animal tissues was somewhat different. The quantity of toxaphene in the commercial meat cuts of the sheep was higher than in the corresponding cuts of steers and was lower in the abdominal and subcutaneous fat. No measurable quantities of toxaphene were found in sheep slaughtered seven months after termination of the feeding of toxaphene-treated alfalfa hay.
--Diephuis and Dunn (61).

Cows were sprayed with toxaphene wettable powder suspension at 0.5 percent concentration equivalent to an average of 10.3 grams of insecticide per animal. The cows were sprayed 4 times from May 15th to August 29th. The maximum organic chlorine content of the milk was 0.6 ppm. and the average was 0.1 ppm., an amount so small as not to definitely indicate the presence of toxaphene in the milk.--Carter *et al.* (39).

Toxicology of toxaphene

When applied to the skin of rabbits toxaphene in solution was fatal at a dose of 780 mg./kg. In multiple dose experiments toxaphene produced fatalities at 200 mg./kg./day. In acute oral toxicity to rats toxaphene is 4 times as toxic as DDT; its LD₅₀ is 60 mg./kg. as compared to 250 for DDT. Toxaphene at 1200 ppm. in the diet can be tolerated by rats for 2 months. Higher levels have not been fed. Toxaphene distribution studies in fat and tissues have not been carried out because no analytical method is available. Toxaphene is principally a liver poison.--Lehman (176).

The acute oral toxicity of toxaphene is 4 times that of DDT. Acutely it is the most toxic of the chlorinated hydrocarbon insecticides. On the skin toxaphene causes moderate irritation. In chronic toxicity to rats 1200 ppm. for 8 weeks produced no effect whereas 330 ppm. in the diet of dogs caused death in 33 days. Liver necrosis is observed in animals chronically poisoned by toxaphene. The hazards of aerosol formulations of toxaphene can only be surmised.--Lehman (177).

Toxaphene is absorbed by the animal, but its fate and whether or not it is excreted in the urine is unknown.—Woodard et al. (328).

Because of the poisonous nature of toxaphene the Insecticide Division of the Production and Marketing Administration, U.S.D.A. (306) on May 5, 1947 suggested a caution statement to be used on the labels of insecticides containing toxaphene.

USE OF TOXAPHENE AS AN INSECTICIDE

Published references have been found giving the results of tests of toxaphene against 158 species of insects. Arranged according to the zoological order to which they belong, these include the following numbers of insect families, genera and identified species that have been experimented with:

Order	Families No.	Genera No.	Species No.
Isoptera	2	2	2
Orthoptera	3	8	14
Anoplura	2	3	5
Mallophaga	1	1	?
Thysanoptera	1	5	6
Homoptera	7	14	17
Hemiptera	5	11	12
Coleoptera	9	27	29
Lepidoptera	13	28	31
Hymenoptera	3	6	6
Diptera	9	16	24
Acarina	4	8	12

Summaries of the results of insecticide tests with toxaphene against many species of insects have been published by Bishopp (18, 19), Bishopp and Knippling (20) and Woodbury (329). Detailed results of tests against identified species of arthropods are presented in the following part of this digest; the information being classified according to the order, family, and genus to which the species belongs.

ISOPTERA

Kalotermitidae

Cryptotermes brevis (Walker), the West Indian dry-wood termite

Wood submerged for 10 minutes in a 1 percent solution of "chlorinated terpenes" remained uneaten for 420 days. A 0.1 percent solution protected the wood for 296 days.--Wolcott (326, 327).

Rhinotermitidae

Reticulitermes flavipes (Kollar), the subterranean termite

In laboratory tests in Florida, 1 part of toxaphene mixed with 10,000 parts of sandy soil remained toxic to termites for 3 years, but 1 to 20,000 failed after 6 months. Toxaphene was less toxic than benzene hexachloride and chlordane to these termites.--Hetrick (137).

ORTHOPTERA

Acrididae

The U. S. Bureau of Entomology and Plant Quarantine recommends toxaphene for the control of grasshoppers at the rate of 1 to 1.5 pounds per acre when applied as a spray or 1.5 to 2.5 pounds when applied as a dust. For use in the poison bran bait 1 pound of toxaphene may be used in place of 6 pounds of sodium fluosilicate.--Wakeland and Parker (308).

The state entomologists of Colorado, Illinois, Indiana, Missouri, Oklahoma, South Dakota, and Wisconsin have also recommended toxaphene for the control of grasshoppers in the form of sprays or dusts at dosages ranging from 1.5 to 3 pounds of toxicant per acre.

The experimental work upon which these recommendations are based is described by many investigators, especially Hinman and Cowan (138), List and Hoerner (181), Parker (228), Shotwell (267), Weinman and Decker (319), and Wilson (320).

Comparative toxicities of toxaphene and other insecticides to grasshoppers

Various investigators have reported that toxaphene kills grasshoppers more slowly than BHC (26, 227, 248), dinitro-o-cresol (227) and parathion (26, 248) and that it is less toxic than BHC (98, 117, 319), chlordane (98, 117, 243, 317, 319), parathion (98, 319), and TEPP (319). Toxaphene is more toxic than DDT to adult grasshoppers (Melanoplus differentialis).--Weinman and Decker (319).

In laboratory tests with M. femur-rubrum nymphs it was found that toxaphene acts principally as a stomach poison. It does not repel grasshoppers. Toxaphene deposits on glass plates were less toxic to nymphs

than were those of BHC (37 percent gamma isomer), chlordane and DDT. This BHC was more than 62 times as toxic as toxaphene as a contact poison. As a stomach poison chlordane was nearly 7 times more active than toxaphene. The speeds of action of chlordane, 37 percent gamma-benzene hexachloride, and toxaphene as stomach poisons at dosages above their LD-50's were almost uniform---Weinman and Decker (318).

In laboratory and field tests of insecticides in dust form in Brazil, their efficiency versus Schistocerca cancellata (Serv.), in decreasing order, was as follows: parathion (0.25 percent), gamma isomer of BHC (1 percent), HFTP (2 percent), TEPP (2 percent), chlordane (5 percent), 4,6-dinitro-o-cresol (10 percent), 2,4-dinitrophenol (10 percent), 4,6-dinitro-o-cyclohexylphenol (10 percent), and toxaphene (20 percent)---Lepage et al. (179).

In tests of emulsion sprays as contact poisons against the differential grasshopper the median lethal dose of certain insecticides as pounds of toxicant per acre was: toxaphene, 1.17; chlordane, 0.49; parathion, 0.05; benzene hexachloride 0.04 and lindane 0.08---Gaines and Dean (105).

Tests made in South Dakota in 1947 showed that a spray of toxaphene, 1.5 pounds per acre gave as good control of the differential grasshopper in corn as did 32 pounds of poisoned bait (3 parts of sawdust and 1 part of bran by volume plus six pounds of sodium fluosilicate per 100 pounds, dry weight, of the mixed bait)---Shotwell (267).

Cage and field tests made in Texas during the spring of 1948 showed that as contact poisons benzene hexachloride and parathion were more effective than toxaphene or chlordane. The action of the four materials represents a combination of contact and stomach poison. Due to the contact action, benzene hexachloride and parathion gave a quicker kill than either chlordane or toxaphene. In order to obtain maximum benefit from the contact action the materials must be applied under good dusting conditions---Gaines and Dean (102).

Mixtures of toxaphene with DDT or with chlordane displayed no synergistic effects against M. differentialis---Weinman and Decker (319).

Tests of toxaphene against specific kinds of grasshoppers are recorded as follows:

Camnula pellucida (Scudd.)

Armitage (13), Hinman and Cowan (138), Wilson (320)

Chortoicetes terminifera Wlk.

Allman and Wright (6)

Melanoplus bivittatus (Say)

Brett and Rhoades (26), List and Hoerner (181), Munro et al. (209), Rhoades and Brett (248).

Melanoplus mexicanus devastator Scudd.

Hinman and Cowan (138)

Melanoplus differentialis (Thos.)

Armitage (13), Gaines (98), Gaines and Dean (102), Graham (117), Hinman and Cowan (138), List and Hoerner (181), Rhoades and Brett (248), Shotwell (267), Weinman and Decker (319), Wilson (320).

Melanoplus femur-rubrum (Deg.)

Armitage (13), Graham (117), Hinman and Cowan (138), List and Hoerner (181)

Melanoplus marginatus Scudd.

Armitage (13), Wilson (320)

Melanoplus mexicanus (Sauss.)

Armitage (13), Brett and Rhoades (26), Hinman and Cowan (138), Munro et al. (209), Rhoades and Brett (248)

Schistocerca americana (Drury)

Griffiths and King (123), Griffiths et al. (124), King and Griffiths (158)

Schistocerca cancellata (Serv.)

Lepage et al. (179)

There seems to be no species variation among grasshoppers in their susceptibility to toxaphene; all species in the same growth stage are killed by it at approximately the same dosage. Approximately 35 species of grasshoppers in North Dakota were killed by toxaphene spray.--Severin (264, 266).

Blattidae

Blattella germanica (L.), the German cockroach

A 2.5-percent wt./vol. solution of toxaphene killed 100 percent of the adult male German roaches, and a solution of DDT of equal strength killed 95 percent.--Parker and Beacher (231).

In a study of the factors involved in poisoning German roaches by exposing them to surfaces treated with several chlorinated hydrocarbons, toxaphene did not show the sharp drop in rate of paralysis found with DDT, chlordane, and benzene hexachloride when the dosage was reduced to

the minimum that caused paralysis. The toxicity of toxaphene compared favorably with that of DDT on constant exposure. However, an exposure period of more than 1 hour was necessary for it to be highly effective. --Hamman (129).

A talc dust containing 50 percent of toxaphene applied at the rate of 100 mg. per square foot proved toxic to roaches, killing 26 out of 30 exposed for 10 seconds and 29 out of 30 exposed for 20 seconds.--Kruse (164).

Among the more promising materials tested as dusts against the German roach in the laboratory and in infested buildings were BHC, toxaphene, and chlordane.--Gould (116).

In laboratory tests on adult cockroaches DDT and toxaphene were relatively ineffective even when freshly applied.--Gahan et al. (97).

Periplaneta americana (L.), the American cockroach

Tested against adult American cockroaches, toxaphene in a urea-formaldehyde surface coating exhibited no toxicity in 48 hours.--Block (22).

Same as for Blattella germanica.--Gahan et al. (97).

Gryllidae

Acheta assimilis F., the field cricket

A 10-percent toxaphene dust at 20 pounds per acre gave satisfactory although slightly lower control than was obtained with a 5-percent chlordane dust. The applications were made in late afternoon to plots which were heavily infested.--Munro et al. (209).

Scapteriscus abbreviatus Scudd., the short winged mole cricket

Wheat bran baits containing 0.8, 3.2, and 6.4 percent toxaphene when sprinkled on top of the soil in pots killed 45, 60, and 50 percent respectively 10 days after treatment.--Hayslip (135, 136).

Scapteriscus acletus R. & H., the southern mole cricket

Toxaphene, 8 pounds of 25-percent wettable powder per 100 gallons of water caused 100 percent mortality after 8 days. The insecticide spray was applied to the surface of the soil at the rate of 1 gallon per 10 square feet.--Hayslip (135, 136).

ANOPLURA

Haematopinidae

Haematopinus adventicius Neum., the hog louse

Only one test, involving a few animals, has been run with toxaphene against the hog louse. A wettable powder spray at 0.2-percent concentration gave apparently complete control of the lice.--U. S. Bur. Ent. and Plant Quar. (300).

Haematopinus eurysternus (Nitz.), the short-nosed cattle louse

H. quadripertusus Fahr., the tail louse

Linognathus vituli (L.), the long-nosed cattle louse

When tested at concentrations of 0.25 and 0.5 percent, toxaphene gave results that were comparable with those obtained with DDT, BHC, and chlordane against both short- and long-nosed cattle lice and the tail louse.--U. S. Bur. Ent. and Plant Quar. (300).

Toxaphene controlled the tail louse, Haematopinus quadripertusus with a single treatment.--Laake (172).

Pediculidae

Pediculus humanus corporis Deg., the body louse

When tested against body lice, as a powder and when impregnated in clothing, toxaphene was found to be slightly superior to DDT in all respects, including minimum toxic concentration, speed of action, and persistence.--Knippling (159).

In tests at Orlando, Florida, toxaphene applied to cloth and evaluated by the beaker test method was effective at a concentration of 0.0025 percent, whereas DDT and 2-pivalyl-1,3-indandione did not adversely affect all the test insects at 0.005 percent. Lice exposed on cloths impregnated with 1 percent of insecticide were paralyzed within 15 minutes by crude and gamma-benzene hexachloride and 2-pivalyl-1,3-indandione, but toxaphene required 5 hours. In arm-and leg tests toxaphene, which was the most effective treatment, remained lethal to lice after four 15-minute boilings in a 1 percent soap solution. Crude and gamma-benzene hexachloride withstood only one boiling, whereas 2-pivalyl-1,3-indandione was rendered ineffective by one laundering.--Eddy and Bushland (76).

Toxaphene is the most promising of the new materials for body louse control. It is as effective as DDT in dust form and when impregnated into garments withstands laundering better than DDT. Toxaphene is highly effective against various species of biting and sucking lice.--Bushland (30).

MALLOPHAGA

Trichodectidae

Bovicola spp., the goat lice

Toxaphene appeared to be at least equal, and perhaps superior, to DDT, chlordane, and BHC against red and yellow goat lice. In limited tests apparently complete control was obtained with dips containing 0.05 percent or a slightly lower concentration of toxaphene. Dips at 0.2-percent concentration have kept goats free of lice for at least 4 months. --U. S. Bur. Ent. and Plant Quar. (300).

THYSANOPTERA

Thripidae

Frankliniella fusca (Hinds), the tobacco thrips

In small plot tests in Louisiana, three applications of 20-percent toxaphene dust to seedling cotton at the rate of 10 pounds per acre at weekly intervals, beginning with the appearance of the first true leaf, gave satisfactory control.--Newsom et al. (221).

Frankliniella tritici (Fitch), the flower thrips

A 20-percent toxaphene-sulfur dust proved effective against thrips on cotton at College Station, Texas, in 1947 and was superior to a 5-percent DDT-sulfur dust.--Gaines et al. (106).

Heliothrips haemorrhoidalis (Bouche), the greenhouse thrips

In laboratory tests with adult female greenhouse thrips 0.0025 percent concentration of toxaphene was required to give fifty-percent kill. --Metcalf (197, 198); Metcalf et al. (199).

Scirtothrips citri (Moult.), the citrus thrips

In California toxaphene was not promising for the control of citrus thrips.--Ewart (81).

Taeniothrips simplex (Mor.), the gladiolus thrips

A 20-percent toxaphene dust was very effective in killing thrips within the leaf folds and flower buds in tests in Florida.--Magie and Kelsheimer (192).

A 5-percent toxaphene dust and a toxaphene emulsion, 0.5 pound per 100 gallons of water, were effective in small field tests, producing from 82 to 90 and from 86 to 95 percent clean flowers, respectively.--Smith (272); Smith and Boswell (273).

Thrips tabaci Lind., the onion thrips

In tests on seedling cotton at Bayview, Texas, in the spring of 1947 the greatest reduction (99 percent) 5 days after application was caused by a 20-percent toxaphene dust applied at the rate of 10 pounds per acre, and the least reduction (63 percent) in the same time was caused by a dust containing 2.5 percent of DDT plus 0.25 percent gamma BHC.--Fife et al. (87).

In tests made at Twin Falls, Idaho, in 1946 and 1947 to control thrips on bulb onions, toxaphene, 1 pound of a 50-percent emulsion per 100 gallons of water, reduced the thrips population 79 percent.--Douglass and Shirck (68).

Unidentified thrips

In Alabama thrips on peanuts can be controlled with 10-percent toxaphene dust applied at the rate of 20 to 25 pounds per acre. Yield increases from the use of this material have varied from nothing to 92 pounds per acre.--Wilson and Arant (321).

HOMOPTERA

Aleyrodidae

Aleurocanthus woglumi Ashby, the citrus blackfly

In experiments performed in Mexico preparations containing 1.67 percent of light-medium emulsive oil with toxaphene at the rate of 0.9 ounce of toxic element per gallon of oil were not so effective as derris powder in oil containing 0.225 ounce of rotenone per gallon of oil.--Plummer and Shaw (237).

Toxaphene exhibited low toxicity.--Woglug et al. (325).

Aphidae

Aphis gossypii Glov., the cotton aphid

A spray of toxaphene wettable powder gave good results against aphids (chiefly this species) on celery in Florida.--Wylie (333).

A 20-percent toxaphene dust applied weekly six times at the rate of 16 pounds per acre was equal to calcium arsenate plus 2 percent nicotine sulfate in reducing high aphid infestations on cotton but was inferior to parathion. Doubling the dosage (32 pounds per acre) did not increase the effectiveness of the treatment.--Loden and Lund (183).

In one case aphids on cotton increased to damaging numbers following applications of toxaphene-sulfur.--Gaines (99).

In Texas in 1947 toxaphene-sulfur dust gave poor control of cotton aphids.--Gaines and Dean (100).

The U. S. Bureau of Entomology and Plant Quarantine (303) in April 1949 recommended for the control of this insect a 20-percent toxaphene dust applied at the rate of 10 pounds of the dust per acre in every application.

Aphis rumicis L., the bean aphid

Dusts containing 3 and 5 percent of toxaphene permitted 10 and 4 percent of the flower stalks of lima beans to be infested with the bean aphid as compared to 16 in the check. In the form of sprays toxaphene wettable powder and toxaphene emulsion were effective. Flower stalks treated with toxaphene 25-percent wettable powder, 4 pounds per 100 gallons of water were 6.5 percent infested; those treated with a 50-percent concentrated emulsion 1:400 were 4 percent infested as compared to 35 percent infestation in the untreated stalks.--Huckett (146).

Toxaphene was about as effective as chlordane against the bean aphid.
--Sun et al. (287).

Bravicornye brassicae (L.), the cabbage aphid

Toxaphene dusts at 3- and 5-percent strengths showed considerable toxicity to the cabbage aphid (62 to 95 percent reduction) and some toxicity to the green peach aphid (54 to 58-percent reduction) in limited tests, but were slower acting than nicotine or benzene hexachloride.--Reid and Cuthbert (247).

Macrosiphum pisi (Klrb.), the pea aphid

Chlordane was more toxic than toxaphene to the adult pea aphid.--Sun et al. (287).

Macrosiphum solanifolii (Ashm.), the potato aphid

In tests on potatoes in New Jersey in 1947 toxaphene, 0.5 pound per 100 gallons of water gave poor control.--Campbell (25).

Myzus persicae (Sulz.), the green peach aphid

Experiments conducted in a tobacco seed bed in Florida showed that dusts containing 10 percent toxaphene with and without 20 percent Fermate gave excellent control of aphids without any injurious effect upon the plants.--Wilson et al. (323).

In Florida in the spring of 1948 toxaphene, 25-percent wettable powder at 4 pounds per 100 gallons of water reduced the number of aphids per 50 tomato leaves from 314 to 91 and the percent of mature leaflets with leaf-miner damage from 81 to 9. Of 5 other insecticides tested only parathion was better than toxaphene against these insects.--Hayslip (136).

An aerosol of 5-percent DDT with 5-percent toxaphene in 40-percent methylene chloride-50 percent methyl chloride was less effective than a 1-percent TEPP aerosol or a 0.66-percent TEPP dust or a 1-percent parathion dust. Tobacco foliage burn resulted if the outlet nozzle of the bomb was held too close to the plant.--Kulash (169).

See under cabbage aphid.--Reid and Cuthbert (247).

Rhopalosiphum rufomaculatum Wilson, the green chrysanthemum aphid

Air currents influenced the toxicity of toxaphene to these aphids. Toxaphene 1:2000 killed 98.3 percent in the absence of air movement and 64.5 percent when the air speed was 3.2 miles per hour.--Dustan *et al.* (74).

Sipha flava (Forbes), the yellow sugarcane aphid

The number of yellow sugarcane aphids present following treatment with 10-percent toxaphene dust for second-generation sugarcane borer control was significantly less than in the plots dusted with cryolite or 50-percent sodium fluosilicate.--Ingram *et al.* (147).

Toxaphene 5- and 10-percent dusts effected a near perfect control of the yellow sugarcane aphid.--Dugas *et al.* (69, 70, 72).

Unidentified aphids

Ten-percent toxaphene dust was less effective than 1-percent parathion dust and 1.5-percent gamma benzene hexachloride against aphids on tobacco in an infested seed bed, but it had very little residual action.--Turner (294, 295).

A 25-percent wettable toxaphene at 4 pounds per 100 gallons of water gave a good reduction of 7 species of aphids.--Hayslip (135).

Cercopidae

Philaenus leucophthalmus (L.), the meadow spittlebug

In tests to control spittlebug on alfalfa in Wisconsin in 1948, toxaphene either in emulsion or water suspension was superior to DDT, chlordane, benzene hexachloride and parathion. A dosage of 1.5 pounds per acre was as effective as dosages up to 6 pounds per acre.--Chamberlin and Medler (40).

Cicadellidae

Circulifer tenellus (Baker), the beet leafhopper

In Utah curly-top disease of tomatoes, transmitted by the beet leafhopper, was not effectively controlled by application of toxaphene dust to tomatoes. The leafhoppers fed upon the tomatoes thus transmitting the

disease before receiving a lethal dose. Four applications were made at weekly intervals, beginning with date of planting and during the period of leafhopper movement.--Dorst and Peay (67).

Eupoasca fabae (Harr.), the potato leafhopper

Toxaphene proved equal to DDT in leafhopper control on Irish cobbler potatoes in 1945.--Parker and Beacher (231).

Two pounds of 25-percent toxaphene per 100 gallons of water gave poor control of all insects.--Campbell (35).

Unidentified leafhoppers

In Alabama four applications of 10-percent toxaphene dust at the rate of 20 to 25 pounds per acre per application were effective in controlling the leafhopper on peanuts.--Wilson and Arant (321).

Cicadidae

Magicicada septendecim (L.), the periodical cicada

In cage tests in Virginia in 1948 the application of 6 pounds of toxaphene 25-percent wettable powder per 100 gallons of water killed about 2/3 of the cicadas.--Woodside (330).

Toxaphene 50-percent wettable powder at 4 pounds per 100 gallons of water was unsatisfactory in tests in orchards in eastern Ohio in 1948.--Cutright (55).

Coccidae

Coccus pseudomagnoliarum (Kuw.), the citricola scale

Toxaphene did not give promising results in California.--Ewart (81).

Pseudococcus maritimus (Ehrh.), the grape mealybug

A 5-percent toxaphene dust killed 50.6 and 33 percent of these mealybugs on yew in two tests at Perry, Ohio.--Neiswander (214).

Psyllidae

Psylla pyricola Foerst., the pear psylla

In tests made in British Columbia in 1947 and in Chelan County, Washington, in 1948, toxaphene proved very effective as a foliage spray.--Carlson and Newcomer (37); Newcomer (216, 217).

In field tests made near Poughkeepsie, N. Y., in 1947, toxaphene 25-percent wettable powder, 4 pounds per 100 gallons of water gave immediate

kill of the nymphs and also showed promise from the standpoint of residual effectiveness. Immediate kill of adults was low.--Hamilton (127, 128).

HEMIPTERA

Cimicidae

Cimex lectularius L., the bedbug

Toxaphene was toxic to nymphs and adults when combined with Thanite (isobornyl thiocyanacetate with related terpenes). A mixture of 0.2 percent toxaphene plus 0.8 percent Thanite killed 43 percent of the eggs. As a residual toxicant (100 mg./sq. ft.), toxaphene is somewhat slower than DDT in its initial action, but equals or surpasses it in final kill. --Parker and Beacher (231).

Coreidae

Leptocoris trivittatus (Say), the boxelder bug

A 2-percent toxaphene emulsion spray killed 90 percent of the bugs within 48 hours and displayed residual properties.--Munro and Post (211).

Leptoglossus phyllopus (L.), the leaf-footed bug

A 20-percent toxaphene dust at 25 pounds per acre gave favorable results against this bug on citrus in Florida.--Thompson and Griffiths (290).

Lygaeidae

Blissus leucopterus (Say), the chinch bug

A dust containing 10 percent of toxaphene killed 100 percent of the bugs after 3 days; a dust containing 5 percent of toxaphene killed 100 percent after 4 days; a dust containing 1 percent of toxaphene killed 42 percent after 4 days. A dust containing 1 percent of dinitro-o-cresol was the fastest acting of all materials tested, killing 100 percent of the bugs in one day.--Kearns *et al.* (152).

Miridae

Adelphocoris lineolatus (Goeze), the alfalfa plant bug

A. rapidus (Say)

In Wisconsin a dosage of 1.5 pounds toxaphene (either in emulsion or water suspension) was very effective.--Chamberlin and Medler (40); Medler and Chamberlin (196).

Dicyphus minimus Uhler, the suckfly

In the lower Rio Grande Valley in 1949 a 10-percent toxaphene plus 40-percent sulfur dust reduced the number of suckflies in 20 net sweeps from 601.7 on untreated tomato plants to 3.7 on treated plants nine days after dusting.--Wene (314).

Lygus hesperus Knight

A dust containing 12.5 percent of toxaphene and 50 percent of sulfur was as effective as a 1-percent parathion dust. These dusts were applied at the rate of 20 pounds per acre on cotton in California in July.--Smith (274).

Lygus oblineatus (Say), the tarnished plant bug

Tests were made in 1948 to control the cat-facing of peaches near Staunton, Va. A spray of toxaphene, 4 pounds of 25-percent wettable powder per 100 gallons of water applied at petal fall resulted in 5 percent of the peaches being scarred as compared to 8.2 percent in the check and 3 percent in the plot sprayed with DDT (2 pounds of 50-percent wettable powder per 100 gallons of water).--Woodside (332).

In cage tests on cotton a 20-percent toxaphene dust was equal to 2-percent parathion dust, superior to 20-percent chlordane dust and inferior to 5-percent BHC dust. In another series of tests against the tarnished plant bug a 10-percent toxaphene dust was inferior to a 2.5-percent parathion dust and a 3-percent gamma BHC dust but superior to a 10-percent chlordane dust.--Scales and Smith (259).

Same as for Adelphocoris lineolatus.--Medler and Chamberlin (196).

Lygus spp.

DDT applied at the rate of 1.25 pounds per acre of seed alfalfa in Arizona gave slightly better Lygus control than did any of the other treatments tested, although 1.5 pounds of toxaphene were almost as effective. The chlordane and toxaphene treatments controlled grasshoppers as well as Lygus spp.--Russell (258).

Psallus seriatus (Reut.), the cotton flea hopper

In tests in Texas during 1947 control 24 hours after treatment was approximately as good from 5-percent toxaphene as from 5-percent DDT; and the residual control from 10-percent toxaphene was about equal to that from 5-percent DDT. In large-scale experiments at Port Lavaca gains in yield were greater from 10-percent toxaphene than from 5-percent DDT. At Waco cotton dusted with toxaphene began fruiting much quicker, and matured and was ready for harvest several weeks earlier than cotton dusted with sulfur. The increase in yield over the check was 30 percent from sulfur alone and 67 percent from both 20- and 10-percent toxaphene.--Parencia and Ewing (226).

In Texas experiments in 1947 a 5-percent toxaphene sulfur dust was effective. Sulfur alone was less effective. One application of these materials gave an economical increase in yield.--Gaines and Dean (100).

In April 1949 the U. S. Bureau of Entomology and Plant Quarantine (304) recommended for the control of this insect a dust containing 10 percent of toxaphene. Two applications will control fleahoppers throughout the season.

Pentatomidae

Euschistus servus (Say)

A dust containing 10 percent toxaphene - 5 percent chlordane - 85 percent pyrophyllite was highly effective in controlling these stinkbugs on spring planted cowpeas on the Texas Gulf coast. A dust containing 18 percent toxaphene - 5 percent DDT - 77 percent pyrophyllite was even more effective.--Riherd (250).

Euschistus spp.

Same as for Lygus oblineatus.--Woodside (332).

Murgantia histrionica (Hahn), the harlequin bug

Laboratory tests on adult bugs indicated that the median lethal dose of a 10-percent toxaphene dust was 8.7 pounds per acre. In cage tests a 10-percent toxaphene dust caused 100 percent mortality 5 days after application in 1947 and 65.1 percent mortality in 1948.--Gaines and Dean (101).

Nezara viridula (L.), the southern green stinkbug

Same as for Euschistus servus.--Riherd (250).

Unidentified pentatomids

In preliminary field tests toxaphene proved effective for the control of cat-facing insects.--Enns (80).

COLEOPTERA

Carabidae

Agonoderus comma (Fabr.)

A 5-percent toxaphene dust applied to soil caused 100 percent of the beetles (introduced into the soil 7 days after dusting) to be moribund after 22 hours. Parathion, chlordane and BHC acted faster than toxaphene and DDT.--Johnson (151).

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Chrysomelidae

Diabrotica longicornis (Say), the northern corn root worm

Plot tests made in Nebraska in 1948 showed that toxaphene as a xylene-kerosene emulsion, 1, 2 or 4 pounds toxaphene per acre or 2 pounds toxaphene plus ammonium nitrate (40 pounds N) per acre gave some reductions in root worm populations and lodging but the reductions were not drastic and did not significantly affect yields.--Muma et al. (207).

Diabrotica undecimpunctata howardi Barber, the spotted cucumber beetle,
the southern corn rootworm

Laboratory and field tests indicated that toxaphene sprays and dust were highly toxic to cucumber beetles.--Parker and Beacher (231).

At Beltsville, Md., in 1947 a spray of toxaphene 25-percent wettable powder (0.1 percent toxaphene) was ineffective in preventing injury to peanut pods by coleopterous larvae including this species.--Dobbins and Fronk (65).

Toxaphene dust at the rate of 10 pounds of toxicant per acre reduced the percentage of corn plants damaged by rootworms from 27 (check) to 19.5. --Kulash (168).

During 1948 significant control of the southern corn rootworm in southeastern Virginia was obtained with toxaphene dust broadcast by hand at the rate of 40 pounds of toxicant per acre over the soil of small plots and raked into the upper 1-2 inches by means of a garden rake on June 3 or July 7-8. At Beltsville a dust mixture containing 10 percent toxaphene applied three times to the foliage at the rate of approximately 2.3 pounds of toxicant per acre-application gave excellent control but a 0.75 percent toxaphene emulsion was of little value. No toxaphene was found in peanuts. Foliage that had received seven applications of 10-percent toxaphene dust (1.9 pounds of toxicant per acre application) contained 17.5 ppm. of organic chlorine.--Fronk and Dobbins (96).

Same as for D. longicornis.--Muma et al. (207).

D. virgifera Lec., the western corn root worm

Same as for D. longicornis.--Muma et al. (207).

Diabrotica vittata (F.), the striped cucumber beetle

Same as for D. undecimpunctata howardi

Epitrix cucumeris (Harr.), the potato flea beetle

In field tests in Delaware during 1947, toxaphene and DDT gave approximately equal control of the potato flea beetle on early potatoes. --Parker et al. (233).

Toxaphene (2 pounds of 25-percent toxaphene per 100 gallons of water) gave poor control of all insects on Katahdin potatoes in New Jersey in 1947.---Campbell (35).

Toxaphene spray (4 pounds of 25-percent wettable powder per 100 gallons of water) reduced flea beetle damage to Katahdin potatoes in Connecticut in 1947 72 percent compared to 86 percent reduction produced by 0.5 pound of micronized DDT spray powder.--Turner and Woodruff (296).

Epitrix hirtipennis (Melsh.), the tobacco flea beetle

In Virginia in 1947 1 pound of toxaphene 25-percent wettable powder plus 3 pounds of Fermate per 100 gallons of water applied to tobacco plant beds produced 94 percent uninjured plants as compared to 17 percent in the check. Toxaphene did not injure the plants.---Dominick (66).

Leptinotarsa decemlineata (Say), the Colorado potato beetle

Loxite (a 50-percent toxaphene) controlled the Colorado potato beetle in Manitoba.---Mitchener (205).

In laboratory tests in France toxaphene was about 1/5 as active as technical benzene hexachloride against Colorado potato beetle larvae. In the field it was necessary for a dust to contain 10 percent of toxaphene to combat this insect.--Raucourt (245).

Coccinellidae

Epilachna varivestis Muls., the Mexican bean beetle

Toxaphene dusts and sprays reduced the beetle population more than did DDT, but neither was equal to rotenone.--Parker and Beacher (231).

Mexican bean beetle adults were very resistant to dust mixtures containing 5 percent toxaphene. Chlordane was about as effective as toxaphene against Mexican bean beetle larvae.--Sun *et al.* (287).

Toxaphene dusts (3 and 5 percent), wettable powder and emulsion, were only slightly effective against Mexican bean beetle on lima beans on Long Island.--Huckett (146).

A dust containing 5-percent toxaphene (30 pounds per acre) gave 85 percent control of the larvae; a dust containing 10 percent toxaphene and 25 percent sulfur (26 pounds per acre) gave 75 percent control.--Brannon (25).

Unidentified lady beetles

Toxaphene was more destructive to beneficial species in Louisiana than any other material included in the tests.--Newsom *et al.* (220, 222).

Curculionidae

Anthomomus grandis Boh., the boll weevil

Ten pounds of 20-percent toxaphene dust per acre is recommended for the control of the boll weevil in Alabama, Georgia (109), Louisiana (184, 223), Mississippi, North Carolina (43), Oklahoma (283, 284), South Carolina (42, 278, 279), and Texas.--Natl. Cotton Council Amer. (212, 213); U. S. Bur. Ent. and Plant Quar.--(298, 299).

The experimental work upon which these recommendations are based has been described by:

Arant (9), Bondy (24), Ewing and Parencia (82, 83, 84), Fife et al. (88), Gaines and Hanna (107), Kulash (165, 167), Walker et al. (309), Young (334), and others.

In Texas in 1947 a 20-percent toxaphene sulfur dust was inferior to a 3-percent gamma-BHC-5-percent DDT-sulfur dust in controlling boll weevil.--Gaines and Dean (100).

In cage tests a 20-percent toxaphene dust was more effective against the boll weevil than parathion (2-percent), chlordane (20-percent), benzene hexachloride (5-percent gamma isomer), or calcium arsenate dusts.--Scales and Smith (259).

In cage tests with boll weevils, high temperature and high humidity had less effect on the toxicity of 20-percent toxaphene than on that of the other organics, although its toxicity was reduced appreciably by high temperatures. In tests conducted at a constant temperature, high humidity reduced the toxicity of calcium arsenate, 20-percent toxaphene, and 20-percent chlordane. Delay in releasing weevils 24 hours after dusting the plants and exposure of the dusted plants to the sun for 4 hours reduced the toxicity of 20-percent toxaphene.--Gaines and Dean (103).

Treatment of cotton squares with 20-percent toxaphene dust killed 36 percent of the boll weevils in the squares; 10-percent toxaphene dust killed 16 percent.--Rainwater (244).

The boll weevil emergence from cotton squares exposed to the vapor of toxaphene was 72 percent compared to 84 percent in the check. Weevils emerged from 63 percent of the squares which had been dusted 4 times with a 20-percent toxaphene dust as compared to 57 percent for the check.--Gaines and Scales (108).

In large scale tests in Texas 20-percent toxaphene dust gave slightly better control of the boll weevil and 10-percent toxaphene dust gave slightly poorer control than calcium arsenate. Aphids caused considerable damage in most of the plots dusted with calcium arsenate, but not in those dusted with toxaphene. As a result of the combined control of both weevils and aphids, both strengths of toxaphene effected higher yields than the

calcium arsenate. In experiments in which the dusted plots were strictly comparable, 20-percent toxaphene produced a gain over the check of 539 pounds as compared to a gain of 360 pounds from calcium arsenate, and 10-percent toxaphene a gain of 494 pounds as compared with 211 pounds from calcium arsenate.--Ewing and Parencia (82).

Toxaphene gave excellent control of several of the most important cotton insects in laboratory, cage, and field-plot experiments at Waco, Texas, during 1946. In cage tests a dust containing 20 percent of toxaphene applied at the rate of 8 pounds per acre controlled the boll weevil as well as did calcium arsenate or benzene hexachloride.--Ivy *et al.* (148).

As a result of field tests made in the Brazos river bottom, Texas, during 1948 it was found that special calcium arsenate (lime free) mixed with either parathion or benzene hexachloride and 20 percent toxaphene-sulfur were equally effective against the boll weevil. These materials were more effective than either the benzene hexachloride-DDT-sulfur or chlordan-DDT-sulfur under the conditions of a hot season and heavy migration.--Gaines and Dean (104).

In tests made in Louisiana in 1947 calcium arsenate-nicotine was superior to toxaphene, and DDT-BHC-sulfur mixture (3-5-40) for the control of boll weevil, bollworm, cotton aphid, cotton fleahopper and tarnished plant bug.--Newsom *et al.* (223).

In April 1949 the U. S. Bureau of Entomology and Plant Quarantine (301) recommended a dust containing 20 percent of toxaphene plus 40 percent of sulfur applied every 4 or 5 days at the rate of 10 to 12 pounds of the dust per acre until weevils are brought under control or until a crop of bolls is set.

Anthonomus signatus Say, the strawberry weevil

In field tests made in New Jersey in 1948 standard lead arsenate-sulfur dust and 5-percent toxaphene dust reduced injury over the untreated check approximately 50 percent, whereas the reduction with 1-percent benzene hexachloride and 5-percent chlordane dusts were 93.5 percent and 85.5 percent respectively.--Christ and Driggers (41).

Toxaphene, 1 pound per 100 imperial gallons of water used with bordeaux 10-10-100 was not particularly effective against the strawberry weevil in Canada. It was less effective than DDT and cryolite but more effective than chlordane, HETP and BHC.--Maxwell (195).

Brachyrhinus ligustici (L.), the alfalfa snout beetle

A 10-percent toxaphene dust applied by hand reduced the infestation 76 percent in 144 hours; applied by helicopter the reduction was 55 percent in the same time.--Gyrisco *et al.* (126).

Chalcodermus aenus Boh., the cowpea curculio

In tests on Purple Hull peas in Texas a 5-percent toxaphene dust applied three times at a dosage of 25 to 30 pounds per acre per application reduced the percentage of infested pods to zero.--Wene (312, 313).

Conotrachelus nenuphar (Hbst.), plum curculio

A toxaphene wettable powder (26.3 percent toxaphene) at 4 pounds per 100 gallons of water was as effective as parathion and benzene hexachloride in orchard experiments in Georgia when the results were measured by the infestation in peach drops.--Snapp (277).

In tests made in Delaware in 1947 plum curculio damage was decidedly more severe with toxaphene than with lead arsenate.--Parker et al. (232).

In North Carolina in 1947 toxaphene (29 percent material) at the rate of 4 pounds per 100 gallons of water decreased the curculio population on peaches as much as or more than 4 pounds of BHC (6 percent gamma isomer) but required a slightly longer time.--Smith (268).

In Missouri one of the promising materials for the control of cat-facing insects, including the plum curculio, is toxaphene.--Enns (80).

Two applications of 2 pounds of 25 percent toxaphene were as effective in reducing total injury to the fruit as two applications of lead arsenate.--Dewey and VanGeluwe (60).

Toxaphene was ineffective.--Parker and Beacher (231).

In cage tests made in Ohio in 1949 a 25-percent toxaphene wettable powder at 4 pounds per 100 gallons of water proved superior to both technical and refined benzene hexachloride but less effective than chlordane, heptachlor, aldrin and dieldrin. The phosphorus insecticides were much more rapid in lethal action and exhibited better residual toxicity to plum curculio than did any of the chlorinated insecticides.--Rings (252).

Cylas formicarius elegantulus (Summers), the sweetpotato weevil

In laboratory tests a dust containing 1 percent of toxaphene in pyrophyllite killed 100 percent of the weevils in 7 days. Used in poison-bait tests 1 part of toxaphene in 80 parts of sweetpotato killed 48 percent of the weevils in 7 days.--Harrison (131).

Hypera postica (Gyll.), the alfalfa weevil

A spray of 2 pounds toxaphene as an emulsion concentrate per acre on alfalfa in Montana in April 1948 caused 68 percent mortality in 24 hours and 92 percent mortality in 14 days.--Hastings and Pepper (132).

Recommended in Colorado for 1949.--List and Hoerner (182).

Trichobaris mucorea (Lec.), the tobacco stalk borer

A spray of toxaphene (2 pounds of 50-percent wettable powder per 100 gallons of water) was less effective than BHC in preventing egg laying. Toxaphene was the slowest of any of the insecticides (DDT, BHC, chlordane) in paralyzing and killing the beetles.--Woodside (331).

Sitophilus granarius (L.), the granary weevil

As a contact poison toxaphene was 1/6 as toxic as DDT.--Stringer (286).

Tyloderma fragariae (Riley), the strawberry crown borer

In laboratory and field tests made in Kentucky in 1949 a 20-percent toxaphene dust gave excellent control.--Ritcher (254).

Dermestidae

Anthrenus vorax (Waterh.), the furniture carpet beetle

Toxaphene was effective against these pests and little or no loss in toxicity in the treated cloth occurred during one year. Toxaphene resists removal from cloth by soap and water but dry-cleaning fluids remove it.--Parker and Beacher (231).

Attagenus piceus (Oliv.), the black carpet beetle

Woolen cloths impregnated with six chlorinated hydrocarbon insecticides at concentrations ranging from 0.5 to 3 percent by weight of cloth were exposed to larvae of the black carpet beetle for 28 days. The following mortalities were obtained: Chlordane 75 to 100 percent; BHC (6 percent gamma) 0 to 100 percent; toxaphene 25 to 52 percent; DDT 15 to 47 percent; TDE 3 to 14 percent; and methoxychlor 1 to 6 percent. According to the visual damage and frass weight noted during these tests, the greatest protection to woolen cloth was obtained with DDT, TDE, chlordane, methoxychlor, toxaphene, and BHC in the order named. Washing and dry cleaning seriously affected the toxicity and the protective value of all the treated cloths, with the exception of those treated with DDT, which resisted one washing at all concentrations.--Laudani and Marzke (174).

Same as for Anthrenus vorax.--Parker and Beacher (231).

Elateridae

Aeolus spp.

The results from one experiment made in Louisiana in 1947 indicate that most of the wireworm injury to fall-planted cane may be prevented by applying 400 pounds of dust containing 1 percent of toxaphene per acre in the furrow with the seed cane at the time it is planted.--Bynum *et al.* (34).

Agriotes mancus (Say), the wheat wireworm

Toxaphene gave very poor control of these wireworms in up-state New York and was not regarded as having promise.--Rawlins et al. (246).

Conoderus spp.

Same as for Aeolus spp.--Bynum et al. (34).

Horistonotus uhlerii Horn., the sand wireworm

Toxaphene, 5 pounds per acre, applied by hand in the row just previous to the 1947 planting of corn gave promising results; the yield per acre was 14.5 bushels as compared to 21 bushels following the treatment with 1 pound gamma BHC per acre and 9 bushels in the check.--Floyd (89).

Limonius agonus (Say), the eastern field wireworm

Same as for Agriotes mancus.--Rawlins et al. (246).

Melanotus spp.

Same as for Aeolus spp.--Bynum et al. (34).

Unidentified Elateridae

Toxaphene has been found to kill wireworms but its use for this purpose is still in the research stage and therefore cannot be recommended at the present time.--Severin (265).

In a laboratory test in Florida toxaphene 25-percent wettable powder at 20 pounds per 100 gallons of water was ineffective against wireworms in sugarcane seed pieces dipped into the mixture immediately before planting. --Hayslip (135).

In tests in Connecticut toxaphene applied as sprays and dusts at 1, 2, 4, and 8 pounds of technical compound per acre was inferior to BHC and chlordane.--Greenwood (120).

Same as for Diabrotica.--Dobbins and Fronk (65).

Scarabaeidae

Cotinis nitida (L.), the green June beetle

In laboratory tests made in Kentucky in 1948 a 20-percent toxaphene dust was ineffective.--Ky. Agr. Expt. Sta. (156).

Popillia japonica Newm., the Japanese beetle

The application of 24 pounds of toxaphene per acre reduced the grub population 92.2 percent in 4 weeks and 3 days. Toxaphene gave good control at the end of 18 months.--Schread (260, 261).

Strigoderma arboricola (F.)

Same as for Diabrotica.--Dobbins and Fronk (65).

Scolytidae

Hylastinus obscurus (Marsh.), the clover root borer

Toxaphene dust at the rate of 4 pounds of toxicant per acre gave 50-percent control and was inferior to dieldrin, aldrin and benzene hexachloride in tests at Fulton, N. Y. in 1949. One application left a residue of 1 ppm. on the clover.--Gyrisco and Marshall (125).

Tenebrionidae

Tribolium confusum Duv., the confused flour beetle

Toxaphene in suspensions and in carbon tetrachloride solutions remained effective on glass surfaces for more than a year. On cement surfaces the duration of effectiveness was very short.--Cotton *et al.* (47).

The mortality of flour beetles exposed to residues from toxaphene formulations 12 days after application of the sprays to unpainted and painted wood at a dosage of 50 milligrams of active ingredient per 1/4 square foot is shown in the following table:

Formulation	Exposure (Hours)	Percent Kill on Wood Surfaces			
		Unpainted	Cold-Water Paint	Flat Oil Paint	Enamel
Emulsion	24	33	3	3	53
Wettable Powder	24	100	60	20	83

--Cotton and Frankenfeld (45).

On glass surfaces the emulsion form of toxaphene was most effective. On unpainted wood surfaces the wettable-powder formulations were by far the most efficient in both initial kill and lasting quality.--Cotton and Frankenfeld (46).

LEPIDOPTERA

Aegeriidae

Melittia cucurbitae (Harr.), the squash vine borer

In experiments at Geneva, New York in 1947 a 2-percent toxaphene dust was effective against the borers.--Carruth and Howe (28).

Crambidae

Diatraea saccharalis (F.), the sugarcane borer

In Louisiana in 1946 a 10-percent toxaphene dust proved superior to cryolite but a 5 percent toxaphene dust was less effective.--Ingram et al. (147). In 1945 it was found that toxaphene, 5 and 10 percent, was equal to undiluted cryolite in effectiveness.--Dugas et al. (69). In 1948 and 1949 toxaphene accounted for significant increases in borer infestations following second generation dusting, due apparently to its injurious effect upon the natural enemies of this pest. At one location toxaphene accounted for losses in yields of cane of 2.72 tons per acre, while cryolite produced an increase in yields of 2.33 tons.--Dugas et al. (20, 72).

Lasiocampidae

Malacosoma americana (F.), the eastern tent caterpillar

In Delaware in 1947 toxaphene, 1 pound per 100 gallons of water, gave 100 percent control on wild cherry growth within one week.--Stearns et al. (282).

Lymantriidae

Euproctis terminalis

In laboratory tests of 5-percent dusts applied at the rate of 10 and 15 pounds per acre, toxaphene was more effective than BHC, chlordane, DDT and lead arsenate.--Petty (236).

Olethreutidae

Carpocapsa pomonella (L.), the codling moth

Toxaphene as a 25-percent wettable powder and as an emulsion concentrate at 1 pound of toxicant per 100 gallons of water was ineffective in protecting Winesap apples in Illinois from worm entry or stings.--Weinman (316).

As a result of orchard tests made at Yakima, Wash. during 1947, Newcomer (215) concluded that toxaphene had some effect on the codling moth.

Toxaphene proved inferior to DDT in producing clean apples (75 vs. 95.5 percent and 85 vs. 99 percent in two schedules).--Parker and Beacher (231).

Toxaphene wettable powder, 1 pound of toxicant per 100 gallons of water, was ineffective in California even when used in a two-spray program. --Michelbacher and Middlekauff (201).

Tests made in Delaware in 1947 showed that toxaphene alone and toxaphene with lead arsenate were approximately 15 percent less effective than lead arsenate alone. This reduction is due wholly to wormy rather than to stung apples. The combination of toxaphene and lead arsenate was no improvement over toxaphene alone. There was no significant difference between treatments in the size of the picked apples. Drop and harvest data agree closely.--Parker *et al.* (232).

Toxaphene was rather highly effective against codling moth, without any resulting build-up in red mite population.--Stearns *et al.* (281).

Grapholitha molesta (Busck), the oriental fruit moth

The substitution of toxaphene for lead arsenate in the early-season peach sprays did not influence twig injury by the Oriental fruit moth or the activity of its parasitic enemies.--Parker and Beacher (231).

Toxaphene decreased twig injury by second-brood Oriental fruit moth somewhat but, at the same time, was responsible for a reduction in the numbers of parasites of this pest.--Stearns *et al.* (281).

Polychrosis viteana (Clem.), the grape berry moth

A spray of 3 pounds of toxaphene per 100 gallons of water gave 65.9 percent control in Pennsylvania in 1947, which was regarded as ineffective. --Cox (48).

Spilonota ocellana (D. & S.), the eye-spotted bud moth

Toxaphene, 2 pounds of 50-percent wettable per 100 gallons of water proved inferior to parathion, TDE, DDT, and basic lead arsenate for the control of this insect on prune in California.--Madsen and Borden (191).

Phalaenidae

Agrotis orthogonia Morr., the pale western cutworm

When dissolved in oil and sprayed in various concentrations on the larvae in a spray tower the LD-50 of toxaphene was 28 and the LD-90 was 50 micrograms per square centimeter. DDT was less toxic, but gamma benzene hexachloride and chlordane were more toxic.--Brown *et al.* (27).

Agrotis ypsilon (Rott.), the black cutworm

A 5-percent toxaphene dust gave good control of Agrotinae during one spring and one fall season in South Carolina. A suspension spray providing a comparable dosage of active ingredient gave excellent reduction of these species. Toxaphene dusts of 3- and 5-percent strengths were, in general, about as effective as similar strengths of DDT. In a fall experiment at the time of thinning, there were significantly fewer caterpillar-damaged plants on plots receiving a 5-percent toxaphene dust than on those given a 5-percent DDT dust. This difference was not so apparent during later observations.--Reid and Cuthbert (247).

Alabama argillacea (Hbn.), the cotton leafworm

The U. S. Bureau of Entomology and Plant Quarantine (305) in April 1949 recommended a 20-percent toxaphene dust for the control of leafworms.

Anticarsia gemmatalis (Hbn.), the velvet bean caterpillar

In Alabama in 1947 a 10-percent toxaphene dust applied at the rate of 25 pounds per acre gave 97.5 percent control of these caterpillars on soybeans 24 hours after dusting and 100 percent control 48 hours after dusting. Toxaphene was faster in action than cryolite.--Arant (10).

Against a heavy population of full grown velvetbean caterpillars, the following controls were obtained on the first and fifth day after the insecticidal application: 10-percent toxaphene, 92 and 94 percent.--Dugas et al. (71).

The velvet caterpillar and army worm attacking peanuts are known as peanut worms. Preliminary investigations indicate that the dusting of peanuts with DDT or toxaphene in sulfur-copper for combined leafhopper-leafspot control during the summer months may greatly reduce or even eliminate the need for later dustings for the control of peanut worms.--Wilson and Arant (321).

Feltia subterranea (F.), the granulate cutworm

Same as for Agrotis ypsilon.--Reid and Cuthbert (247).

Heliothis armigera (Hbn.), the corn earworm, the bollworm, the tomato fruit worm

In tests made in 1946 in New Jersey a 3-percent toxaphene talc dust was inferior to a 3-percent TDE dust, equal or superior to a 20-percent lead arsenate dust and superior to a 3-percent methoxychlor dust in controlling corn earworms on early sweet corn.--Pepper and Wilson (234).

In the Everglades area of Florida a 5-percent toxaphene dust proved ineffective in preventing corn earworm damage.--Hayslip (135).

A 10-percent toxaphene dust produced 47.3 percent marketable sweet-corn ears as compared to 13.9 percent in the check.--Kelsheimer (154).

In tests made on Long Island in 1948 a 10-percent toxaphene dust applied three times per ear (4, 6 and 8 days after the mean silking date) produced 75 percent or more noninfested ears at harvest.--Butler and Carruth (32).

A 25-percent wettable toxaphene at 4 pounds per 100 gallons of water was effective against the tomato fruit worm in Florida.--Hayslip (135).

Toxaphene, 1- and 0.25-percent solutions in refined mineral oil injected into tips of ears of Golden Cross Bantam sweet corn was about as effective as DDT. Applied as high pressure aerosols 1-percent oil solutions of DDT, TDE, toxaphene, and chlordane all gave good control (87 to 97 percent wormfree ears).--Anderson and Hashe (7).

Toxaphene talc dusts (both 5-percent and 10-percent) applied 4 times in the lower Rio Grande Valley of Texas in 1949 did not give commercial control of the earworm feeding in the whorls of sweet corn. Of the materials tried (DDT, chlordane, toxaphene, methoxychlor, aldrin and parathion) only parathion as a 1-percent dust gave good control.--Wene and Blanchard (315).

In tests made in Louisiana in 1947 toxaphene, DDT and parathion when applied once to the maturing ear gave significant controls over check plots; however, the oil-pyrethrum treatment gave a control that was significant over all other treatments and checks. Untreated plots contained only 18 percent of the ears free of worm injury, whereas, the oil-pyrethrum treatment gave 74 percent of the ears free of injury. The degree of control secured by the other insecticides ranged between that on the untreated plots and that on the oil-pyrethrum plots.--Floyd and Smith (90).

In North Carolina in 1947 a 5-percent toxaphene dust gave less than 50 percent worm-free ears.--N. Car. Agr. Expt. Sta. (224).

Good control of the bollworm with toxaphene has been reported by: Fife et al. (88), Gaines and Dean (100, 104), Ivy et al. (148), Newsom et al. (223), N. Car. Agr. Expt. Sta. (224), and Sparks (279).

For the control of the bollworm on cotton the U. S. Bureau of Entomology and Plant Quarantine (302) in April 1949 recommended a 20-percent toxaphene dust. Whenever the red spider must also be controlled the dust should include at least 40 percent of sulfur.

Same as for Agrotis ypsilon.--Reid and Cuthbert (247).

Laphygma frugiperda (A. & S.), the fall armyworm

A 5-percent toxaphene dust applied to field corn in July at Norfolk, Va., reduced the infestation 56 percent after 24 hours and 72 percent after 48 hours. Toxaphene was used successfully by many growers in the Norfolk area.--Hofmaster and Greenwood (144).

A 10-percent toxaphene dust gave effective control of this insect on corn under the most severe conditions of infestation.--Tissot and Kuitert (291).

Fifteen percent toxaphene gave very little control of a heavy infestation in Louisiana in 1948.--Dugas et al. (22).

A 20-percent toxaphene dust applied at the rate of 10 pounds per acre was effective in controlling armyworms in a Ladino clover pasture in North Carolina.--Kulash (166).

At the Everglades Experiment Station, Belle Glade, Fla., a 25-percent wettable toxaphene at 4 pounds per 100 gallons of water reduced the percentage of infested buds of corn from 80.5 to 7.4 four days after the second treatment. A poisoned wheat bran bait containing 5-percent of toxaphene reduced the percentage of infested buds from 94.9 to 13.1 in one block and from 94.8 to 2 in another block four days after treatment.--Hayslip (134, 135).

Same as for Agrotis ypsilon.--Reid and Cuthbert (247).

Platysenta sutor (Gm.)

A 20-percent toxaphene dust killed 93.7 percent of these worms on celery in Florida one day after treatment.--Hayslip (135).

In Florida toxaphene (3 pounds of 40-percent wettable powder per 100 gallons of water) is recommended for the control of green cutworm on celery.--Hayslip (136).

Trichoplusia ni (Hbn.), the cabbage looper

Toxaphene was inferior to DDT but the differences were not significant.--Dills and Odland (64).

See also under imported cabbage worm.--Reid and Cuthbert (247).

Pieridae

Colias philodice eurytheme Bdv., the alfalfa caterpillar

A 10-percent toxaphene dust applied at the rate of 2.2 pounds of toxicant per acre gave 83.9 percent control in 24 hours and 97.8 percent control in 96 hours.--Smith and Allen (276).

Pieris rapae (L.), the imported cabbageworm

In tests made in Pennsylvania toxaphene, at 3-percent, was found to be very effective. At 2-percent it did not give significantly different results from DDT.--Dills and Odland (64).

In the one experiment in which they were compared, a 5-percent toxaphene dust was superior to a 3-percent one against the imported cabbage worm at the time of the first of two insect counts and tended to be superior against the cabbage looper at the third and most important count.---Reid and Cuthbert (247).

Psychidae

Acanthopsyche junodi (Heyl.), the wattle bagworm

In laboratory tests a 5-percent BHC dust appeared to be slightly more effective than toxaphene and chlordane against the first two instars but there was some evidence that toxaphene was more toxic than BHC or cryolite against third and fourth instar larvae.---Petty (236).

Thyridopteryx ephemeraeformis (Haw.), the bagworm

Toxaphene gave a 92 percent control in one week and 59 percent control over a four-week period.---Stearns et al. (282).

Pyralididae

Cnephiasia longana (Haw.), the omnivorous leaf tier

In tests on the San Francisco peninsula in 1948, toxaphene 60-percent emulsion at 1 quart per 100 gallons of water was ineffective in controlling these caterpillars on asters.---Pritchard et al. (239).

Elasmopalpus lignosellus (Zell.), the lesser cornstalk borer

Toxaphene, 1 pound per acre, was less effective than DDT, 10 pounds per acre.---Dugas et al. (23).

Pyraustidae

Desmia funeralis (Hbn.), the grape leaf folder

In 1947 a dust containing 5 percent of toxaphene and 50 percent of sulfur applied at the rate of 30 pounds per acre at Exeter, California was less effective than a 50-percent cryolite, 5-percent DDT, 40-percent sulfur dust, or a 1-percent parathion, 55-percent sulfur dust.---Frazier and Barnes (93).

Hymenia fascialis Cramer, the Hawaiian beet webworm

A 10-percent toxaphene dust applied at the rate of 40 to 50 pounds per acre to fall spinach at Norfolk, Va., gave highly satisfactory control, no living larvae being found after 72 hours. At the end of 24 hours the effect of the treatment was not sufficiently pronounced to distinguish affected larvae from normal larvae.---Greenwood and Hofmaster (121).

Pyrausta nubilalis (Hbn.), the European corn borer

A 5-percent toxaphene dust applied at the rate of 20 pounds per acre was less effective in tests made in Illinois in 1947 than 5-percent DDT dusts.--Apple and Decker (8).

Toxaphene gave fair control in 1946 field tests in Illinois on yellow sweet corn.--Decker et al. (56).

In tests in Maine in 1948 toxaphene dust was somewhat less effective than Ryania and DDT dusts applied in the same manner and in comparable amounts.--Hawkins and Thurston (133).

Sphingidae

Protoparce sexta (Johan.), the tomato hornworm

P. quinquemaculata (Haw.), the tobacco hornworm

Toxaphene was tested as a 10-percent dust, as a 5-percent toxaphene plus 3-percent DDT dust and as a 40-percent wettable powder, all in combination with sulfur for the control of the sulfur mite. The 10-percent toxaphene dust at the rate of 30 pounds per acre gave satisfactory control of caterpillars and the toxaphene-DDT combination gave excellent control. Toxaphene residues on tomatoes were less than 1 ppm. following the application of dusts and 4.4 ppm. following the application of a concentrated spray (7.5 pounds of 40-percent wettable to 12.5 gallons of water). Washing the tomatoes reduced this residue to 1.9 ppm.; 0.8 ppm. was found in the juice and 15.3 ppm. in the tomato pomace.--Michelbacher et al. (202).

See under Heliothis armigera.--Hayslip (135).

Tineidae

Tineola bisselliella (Hum.), the webbing clothes moth

Same as for Anthrenus vorax.--Parker and Beacher (231).

Tortricidae

Argyrotaenia citrana (Fern.), the orange tortrix

A 10-percent toxaphene dust gave 82 percent control. The best control, 94.5 percent, was given by a 5-percent TDE dust.--Rosenstiel (255).

Argyrataenia velutinana (Wlk.), the red-banded leaf roller

In tests in New York in 1948 a 25-percent toxaphene wettable powder at 3 pounds per 100 gallons of water gave 77.9 percent control (based on feeding areas per 100 fruits). The best control, 100 percent, was given by TDE, 2 pounds per 100 gallons of water.--Glass and Chapman (114).

In tests in a plum orchard in Ohio in 1948 the extent of leaf roller injury was less in plots treated with parathion, acid lead arsenate, toxaphene, and refined benzene hexachloride, whereas it was more severe in the technical benzene hexachloride and chlordane plots.--Rings (251).

HYMENOPTERA

Apidae

Apis mellifera L., the honeybee

Toxaphene at a dilution of 1:4000 showed little toxicity to bees. The time required for a 100-percent mortality of bees treated with toxaphene was about the same as that of the unsprayed bees.--Butler and Shaw (23).

Eckert (75) determined the comparative toxicities of the newer insecticides to the honeybee. Of the 9 materials tested toxaphene was the least toxic. The LD-50 in 72 hours was 22 micrograms per bee.

In laboratory tests bees in cages were dusted with a pre-determined dose of insecticide at 40 pounds pressure. The dust was allowed to settle for 30 seconds after which the bees were immediately transferred to other cages for observation. Toxaphene was practically non-toxic, 20 percent toxaphene-40 percent sulfur giving only 2.5 percent mortality at 36 pounds per acre.--Weaver (311).

Cephidae

Cephus cinctus Nort., the wheat stem sawfly

A 10-percent toxaphene dust applied at the rate of 20 pounds per acre to hard spring wheat permitted a 66 percent infestation as compared to 68 percent in the check plot.--Munro *et al.* (210).

Formicidae

Lasius niger alienus americanus Emery, the cornfield ant

Toxaphene in the form of a 29.3 percent wettable powder applied at the rate of 1.7 pounds of toxicant per 1,000 square feet caused only 1.4 percent reduction in the number of ant hills after 47 days.--Kerr (157).

Pogonomyrmex barbatus (F. Smith), the red harvester ant

Strong, well established colonies located in a typical Texas Gulf Coast pasture were selected for the test. Each nest was treated five times during the test by strewing the dust over and around it. The duration of the test was 83 days. At the end of the test no colonies had been eradicated. Of the five colonies treated with 20-percent toxaphene three were in a weakened condition, one showed very little activity, and one was normal.--Riherd (249).

Solenopsis saevissima var. richteri Forel, the imported fire ant

Experiments were conducted at two locations in Alabama. The most effective treatment of individual hills was opening the mound and mixing insecticide with soil in the mound. Two ounces of 20-percent toxaphene dust applied in this manner was effective.--Eden and Arant (79).

In Mississippi in 1947 several chemicals, including 25-percent toxaphene dust, were found very effective in laboratory tests when blown through the tunnels in the mounds with a small plunger duster having a short spout to penetrate the outside crust of the mound.--Lyle and Fortune (186).

Wasmannia auropunctata (Roger), the little fire ant

An emulsion of toxaphene (0.5 pound of toxicant in 0.5 gallon of No.2 fuel oil per 100 gallons of water) was as effective as chlordane or DDT when sprayed on citrus trees. Fuel oil alone was ineffective. The infestation was held to a low level for 12 weeks.--Osburn (225).

DIPTERA

Agromyzidae

Liriomyza flaveola (Fall.), the serpentine leaf miner

In 1947 field tests to control this leaf miner on asters in southern California, toxaphene 50-percent emulsifiable spray, two applications at a dosage of 1.25 pounds toxicant per 100 gallons of water, permitted 9.9 miners per stem as compared to 32.6 in the check. Toxaphene proved more effective than chlordane or parathion and did not injure asters.--Jefferson and Pence (149, 150).

Calliphoridae

Callitroga macellaria (F.), the secondary screw-worm

Phormia regina (Meig.), the black blow fly

Toxaphene was the most promising of six materials tested as fleece worm larvicides at Kerrville, Texas during 1947. Artificially infested sheep were treated with benzene solution, water suspensions, and emulsions of toxaphene and other insecticides. The sheep were infested by implanting the newly hatched larvae of several blow flies, principally these species, on a very small piece of ground beef which had been rubbed into the wool on the animal's rump. Each of the chemicals was used at a concentration of 2 percent. Eight of the 10 sheep treated with toxaphene were protected against reinestation for the entire time they were in test, 55 to 82 days.--Graham and Eddy (119).

Little is known about the value of this material for controlling either of these parasites under practical conditions.--U. S. Bur. Ent. and Plant Quar. (300).

Culicidae

Aedes aegypti (L.), the yellow-fever mosquito

A single dose of toxaphene, undiluted at 300 mg./kg. and as a 10-percent solution in corn oil at 5 mg./kg. was given rabbits. Of mosquitoes feeding on these rabbits 10 percent died after 2 days when the rabbit was given undiluted toxaphene and 25 percent died after one day when the rabbit was given toxaphene in oil.--Knipling et al. (163).

Toxaphene was very much less effective than DDT, BHC, and chlordane when tested as space sprays against adult mosquitoes and was less effective than DDT as a residual poison after 36 weeks on plywood.--Gahan et al. (97).

Toxaphene, chlordane, BHC, and methoxychlor are less toxic to mosquito larvae and are more toxic to gold fish than DDT.--Ginsburg (110).

Aedes sollicitans (Wlk.), the salt-marsh mosquito

In laboratory and field tests toxaphene compared favorably with DDT. --Parker and Beacher (231).

In favorable weather four insecticides when sprayed on the ground reduced mosquito populations for 11 days, and their comparative value as residual treatments appeared to be in the following order: DDT, BHC, chlordane, and toxaphene.--Fluno et al. (91).

Toxaphene and DDT proved equally and highly toxic to larvae and pupae of Aedes sollicitans. At the rates of 0.2 and 0.4 pounds per acre, no adverse effect on other aquatic life was observed from either material. At the rate of 1.0 pound per acre, however, a kill of predaceous diving-beetles (Dytiscidae), small fish (up to one and one-half inches in length), and fiddler crabs was recorded for both insecticides, with a greater mortality of all forms in the case of toxaphene.--Stearns et al. (280).

Aedes spp.

In laboratory tests DDT and gamma BHC were about equally toxic to mountain species and toxaphene, chlordane, and methoxychlor were somewhat less effective.--Roth et al. (257).

A fuel oil solution of toxaphene applied at the rate of 0.1 pound toxicant per acre caused an average mortality of 80 percent of the larvae in 48 hours; a similar application of DDT gave 93 percent mortality. Toxaphene was inferior to DDT applied to the surface of the streams against black fly larvae.--Travis (292).

In prehatching treatment toxaphene dissolved in fuel oil applied at the rate of 1 pound per acre gave 46 percent control of the larvae; the same dosage of DDT in fuel oil gave 83 percent control.--Travis et al. (293).

A fuel oil solution of toxaphene was less effective than either a fuel oil solution or a water emulsion of DDT against larvae of both Aedes and Culiseta. Five-percent toxaphene in fuel oil at 0.2 pound toxicant per acre killed 74 percent of Aedes larvae in 48 hours; the same dosage of DDT killed 98 percent. These tests were made in Alaska.--Gjullin et al. (113).

In tests against arctic species of Aedes larvae made at Ft. Churchill, Manitoba, Canada in 1948 and 1949, toxaphene was less toxic in oil solution than DDT but gave a comparable kill as an emulsion at a dosage of 0.1 pound per acre.--McDuffie et al. (188).

Anopheles quadrimaculatus Say, the common malaria mosquito

Toxaphene was one of 175 compounds out of 6,000 tested which caused 50-percent mortality of larvae in 48 hours at 1 ppm. or less. Comparative tests of DDT and toxaphene yielded the following results:

	Concentration ppm.	Mortality	
		in 24 hrs.	in 48 hrs.
DDT	.01	100	—
Toxaphene	.01	28.3	98.3
DDT	.005	96.6	98.3
Toxaphene	.005	3.3	58.3
DDT	.0025	58.3	85.0
Toxaphene	.0025	1.6	30.0

--Deonier et al. (57).

Field tests in occupied and unoccupied structures indicate residual toxicity of three months or longer with toxaphene. The irritant effect produced by DDT is much less apparent with toxaphene.--Cutkomp (54).

The order of diminishing residual effectiveness of various insecticides over a 26-week period is DDT, BHC, chlordane, toxaphene, and TDE.--Fay et al. (86).

Same as for Aedes aegypti.--Gahan et al. (97).

Insectary-reared Anopheles quadrimaculatus mosquitoes were released in rooms which had been sprayed with insecticides at the rate of 200 mg. of the active ingredient per square foot. Toxaphene, whether applied as a 5-percent xylene emulsion or as a 5-percent suspension from a 25-percent wettable powder was very slow acting and seemed to have a comparatively short residual life.--McCauley et al. (187).

Unidentified mosquitoes

In laboratory tests toxaphene proved highly toxic to larvae of eleven species of California mosquitoes.--Michelbacher (200).

When employed in space sprays toxaphene is less effective than DDT against both flies and mosquitoes, and considerably less effective when used in aerosols. It has very little knockdown action and acts slowly. Although highly toxic to mosquito larvae, it is slightly less active than DDT.--Knippling (159, 160, 161, 162).

Tests on the control of mosquito adults during the 1948 season in Alaska were conducted to determine the size of area necessary to treat in order to prevent infiltration in annoying numbers from the surrounding unsprayed areas, to obtain information on the number of times an area must be treated to protect a community from mosquitoes, and to establish the minimum effective dosage of DDT. Formulations tested included standard 20 percent DDT airplane spray containing either 40 percent toxaphene and 40 percent fuel oil; 28 percent toxaphene and 52 percent fuel oil; or 15 percent toxaphene and 65 percent fuel oil. Fuel oil was used as a diluent to obtain reduced dosages. It was concluded that a dosage of 0.1 pound of DDT per acre is adequate if applied under suitable wind conditions.--Blanton *et al.* (21).

Hippoboscidae

Melophagus ovinus (L.), the sheep tick

Puparia were dipped in 0.5 percent suspension of insecticide and held at room temperature (67-80° F.) or at a constant temperature of 80° F. and a relative humidity of 50 to 70 percent. Toxaphene caused little if any mortality of pupae and the addition of a wetting agent did not enhance its effectiveness.--Hoffman (140).

Ticks were placed on cloth patches treated with an acetone solution of the insecticide. Of the 20 insecticides evaluated 15 failed to give 100 percent mortality in 24 hours after 30 minutes exposure on cloth treated at the rate of 25 mg. of insecticide per square foot. Among the insecticides that failed were DDT, TDE, methoxychlor, chlordane, toxaphene, cube powder, crude benzene hexachloride and its alpha, beta and delta isomers. Parathion was the most effective material tested, causing 100 percent mortality in 24 hours at 1.5 mg. dosage per square foot.--Gjullin (111).

Sheep ticks exposed for 120 minutes to 24 mg. toxaphene per square foot at 70° F. suffered 57-percent mortality and at 90° F. they suffered 94 percent mortality. Toxaphene and BHC killed more ticks at the higher temperature, whereas DDT, TDE and methoxychlor caused considerably higher mortality of sheep ticks at 70° F. than at 90° F.--Hoffman *et al.* (143).

Dipping tests with wettable powders showed that 0.2 and 0.5 percent concentrations of all the chlorinated hydrocarbons caused complete to nearly complete control of sheep ticks during the entire 110-day period of the test. Wool samples collected from the treated sheep and exposed to houseflies showed a high degree of toxicity for all chemicals at the 0.05-percent concentration. When Shropshire ewes in heavy fleece were sprayed with 2.7 quarts of the chlorinated hydrocarbons at 0.2-percent strength, none of the treatments consistently killed all the sheep ticks during the test period. Chlordane, BHC, toxaphene, and methoxychlor gave better results than DDT and TDE.--Fairchild *et al.* (85).

Against the sheep tick toxaphene was superior to DDT when used as either a dip or a spray, but less effective than BHC and chlordane. In a few tests complete control was obtained with dips containing 0.05, 0.2, and 0.5 percent of the insecticide. However, its action appeared to be slower than that of the other insecticides.--U. S. Bur. Ent. and Plant Quar. (300).

Hypodermatidae

Dermatobia hominis (L. jr.), "Berne", the human bot fly

Toxaphene had no effect on encysted larvae.--Laake (172).

Hypoderma bovis (L.), the northern cattle grub

H. lineatum (De Vill.), the common cattle grub

Toxaphene was tried in 5 formulas all of which gave zero mortality except one (50 percent lanolin, 25 percent toxaphene and 25 percent linseed oil) which gave 80 percent mortality when applied by spatula.--Telford (289).

In small-scale tests toxaphene did not control larvae of the common cattle grub.--U. S. Bur. Ent. and Plant Quar. (300).

In laboratory tests a 1.5-percent aqueous suspension of toxaphene prevented the eggs from hatching. In tests at Kerrville, Texas during 1948 nine applications at two week intervals beginning in January of a 2-percent suspension of toxaphene reduced the average number of grubs per animal from 39.9 in the untreated check to 23.1.--Graham (118).

Itonididae

Monarthropalpus buxi Lab., the boxwood leaf miner

Toxaphene, 2 pounds to 100 gallons of water gave 100 percent control.--Stearns *et al.* (282).

Muscidae

Hylemya brassicae (Bouche), the cabbage maggot

A 0.05 percent spray of toxaphene reduced the average infestation in radishes from 52.4 to 12.2 percent.--Dills and Odland (62, 63).

Toxaphene dusted on cabbage, cauliflower, and broccoli in Washington three weeks after the plants were up gave poor maggot control. This dust, when applied by a fertilizer or duster attachment on the transplanter, gave practically no control. Toxaphene caused no plant injury.--Stitt and Eide (285).

Hylemya cilicrura (Rond.), the seed-corn maggot

A 5-percent toxaphene dust used at the rate of 0.5 pound per bushel of bean seed was without value; also when applied to the soil at 80 pounds per acre.--Ristich and Schwardt (253).

Muscidae

Musca domestica (L.), the house fly

The effect of temperature on speed of knockdown and mortality of houseflies exposed to residues of several chlorinated hydrocarbons was determined by exposing houseflies (1) continuously at constant temperatures of 70° and 90° F. and (2) for predetermined periods (1 to 20 minutes) at 70° and 90° and then holding them for 24 hours at the same temperature at which they were exposed. At a dosage of 50 mg. per square foot toxaphene required 299 minutes for knockdown at 70° F. and 191 minutes at 90° F.--Hoffman and Lindquist (142).

As a space spray toxaphene was considerably less effective than DDT, chlordane, and BHC.--Gahan et al. (97).

In Brazil spraying barns and stalls with 0.5-percent toxaphene emulsion quickly eliminated heavy population of house flies and kept the buildings practically free from flies for 6 weeks, when the observations were discontinued.--Laake (172).

In residual toxicity tests DDT and gamma BHC were initially the most toxic compounds followed by chlordane, TDE, and toxaphene. BHC gave the most rapid knockdown, followed by DDT, TDE, chlordane, and toxaphene. The order of persistence of the residual treatments was, from the most to the least, DDT, TDE, toxaphene, chlordane, and BHC.--Bruce (28).

When tested as a fumigant toxaphene caused high mortality.--Hoffman and Lindquist (141).

DDT proved superior to toxaphene as a space spray at all concentrations less than 0.10 percent and at all volumes less than 0.30 milliliters. Toxaphene does not give knockdown. As a residual toxicant, toxaphene compares favorably with DDT. However, DDT causes paralysis of the flies in a considerably shorter period of time than toxaphene. There was no difference in the efficiency of the DDT and toxaphene deposits after nearly 12 months' exposure to diffused light in the laboratory.--Parker and Beacher (231).

Toxaphene was less effective than DDT against house flies from the standpoint of both initial killing action and residual action.--U. S. Bur. Ent. and Plant Quar. (300).

Nitrocellulose and urea-formaldehyde surface coatings containing 20-percent of toxaphene were more toxic after 26 to 35 weeks than when first applied, probably due to migration of the toxicant to the surface.--Block (23).

Various surfaces, including pebbled glass, unpainted wood, Celotex, Texolite water paint, whitewash plus toxicant, and whitewash on which the toxicant was sprayed after drying, treated with comparable 10 percent (by weight) water emulsions of toxaphene and DDT to give a theoretical deposit of 100 mg. of toxicant per sq. ft., were compared for residual effectiveness against the housefly over a period of 225 days. DDT proved superior to toxaphene in speed of knockdown and in six-hour mortality for all surfaces tested.--Beacher and Parker (17).

See also under Unidentified mosquitoes.--Knipling (159, 160).

See under Anopheles quadrimaculatus.--Fay et al. (86). In these tests against adult house flies the water-wettable toxaphene was somewhat superior to the toxaphene-xylene emulsion, but neither combination was entirely satisfactory.

Resistant houseflies

Wilson and Gahan (322) found that a special strain of houseflies that was comparatively resistant to DDT space sprays was also resistant to other insecticides including toxaphene. On the other hand Barber and Schmitt (14, 15) in residual toxicity tests (144 mg. toxicant per sq. ft.) found that flies of the Ellenville, N. Y. line that were highly resistant to DDT and related compounds showed no resistance to certain other unrelated chemicals including toxaphene.

The susceptibility or resistance of the various strains of flies studied was determined from data obtained by topical applications of the toxicant to the thorax of female houseflies. Acetone solutions of the insecticides were used in all tests. The dosage-mortality data were used to calculate the LD-50 values in terms of micrograms of toxicant per gram weight of fly. The 24-hour LD-50 of toxaphene to the NAIDM strain of flies was 29.16 (DDT = 16.8) whereas to flies that had become resistant to DDT (18,728) this value was 76.4 micrograms per gram weight.--Bruce (29).

In Denmark DDT-resistant and control flies reacted uniformly toward toxaphene.--Keiding and Van Deurs (153).

Siphona irritans (L.), the horn fly

Toxaphene wettable powder at a concentration of 0.5 percent protected dairy cattle for an average of 31 days and was equal to DDT. Of all of the materials tested toxaphene gave the slowest knock-down of horn flies.--Smith (270).

Toxaphene wettable powder spray at 0.5-percent concentration gave excellent horn fly control. In Kansas the average days' protection was 27 and in Missouri 42 because the Missouri test herds were less exposed to untreated cattle than were the Kansas herds.--Laake (171). These tests were made on beef herds, using high-pressure sprayers and two quarts were applied to the topline of each animal.--Cuff (50).

Cattle sprayed with 0.5-percent toxaphene wettable powder on the topline went 50.2 days before the fly count averaged 25; those sprayed on both the topline and under went 62.4 days. The corresponding figures for the 0.5-percent DDT wettable powder spray were 41.5 and 42 days.--Cuff (51).

Toxaphene at 0.5-percent concentration has given results similar to DDT for the control of horn flies. Although it is somewhat slower in killing flies coming to treated animals, and under certain conditions might appear to be inferior, final control has in general been comparable with that obtained with DDT.--U. S. Bur. Ent. and Plant Quar. (300).

In laboratory knock-down tests against the horn fly, small screenwire cages were dipped in preparations containing 0.5 percent of different chlorinated hydrocarbon insecticides. The methoxychlor caused complete knock-down in 5 minutes, DDT in 8, TDE in 17, chlordane in 53, and toxaphene in 73 minutes in tests made 24 hours after the cages had been dipped. After 2 months' exposure the methoxychlor, DDT, TDE, toxaphene, and chlordane caused complete knock-down of flies in 12, 62, 152, 248, and 360 to 720 minutes, respectively. The knock-down of flies exposed to animals treated with the insecticides was the same as that determined in the laboratory, except that a longer time was required. In semi-field tests best results were obtained with DDT and toxaphene. In most of the tests wettable powders proved superior to emulsions regardless of the concentration of insecticides tested.--Eddy and Graham (77).

In tests at Kerrville, Texas during 1948 DDT, TDE, methoxychlor and toxaphene applied as 0.5-percent emulsions to Jersey cows performed similarly. The protective values were about equal, whether 1 or 2 quarts of the insecticide were applied over the entire body or 1 quart over the dorsal half of the cow's body. When herds were sprayed on the under line only, fly-free periods were diminished.--McGregor (190).

Stomoxys calcitrans (L.), the stable fly

The speed of knockdown and kill, and the duration of effectiveness of 11 of the more recently developed organic insecticides were studied in laboratory tests against the stable fly. Two 14-mesh copper-wire cages were dipped in a 1-percent solution of each test material in acetone. One cage was held indoors while its duplicate was stored outdoors, fully exposed to the effects of the weather. In the tests made 24 hours after the cages were treated, DDT and methoxychlor proved to be the fastest acting compounds and toxaphene and chlordane the slowest acting.--Eddy and McGregor (78).

Under comparable practical conditions DDT, TDE, methoxychlor, toxaphene, and chlordane in barn and premises treatments seem to be equally effective in reducing the number of houseflies and stable flies that enter the milk barns on treated farms.--Muma and Hixon (208).

See under Tabanidae.--U. S. Bur. Ent. and Plant Quar. (300).

Simuliidae

Simulium latipes Fries

S. venustum Say

S. vittatum Zett.

Toxaphene as an emulsion was effective against black fly larvae at a concentration of 4 ppm.; DDT was effective at about 1/6 this concentration.--Gjullin *et al.* (112).

Toxaphene, tested in the form of a 25-percent emulsion concentrate with 65 percent xylene and 10 percent Triton X-100 against blackfly larvae in streams was ineffective at 2.46 ppm./min., or 1:6,000,000 for 15 minutes.--Hocking *et al.* (139).

See under Aedes spp.--Travis (292).

Tabanidae

The effect on horse fly populations of aerial sprays applied to wooded areas was studied. The insecticides were applied from a plane equipped with a standard spray boom. Ten-acre plots were treated with 2 pounds per acre of one of the following insecticides, dispersed as a 10-percent solution in a mixture of cyclohexanone and No. 1 fuel oil: methoxychlor, DDT, toxaphene, and chlordane. The effectiveness of the materials was determined by counting flies attacking draft horses led through the test plots 1 day before spraying and 1, 2, 3, 5, and 7 days after treatment. The results appeared somewhat erratic, and no appreciable effect on fly populations could be demonstrated for any of the insecticides tried. Tabanus abactor and T. sulcifrons were the two most abundant species. T. atratus, T. vittiger, T. mularis, and T. venustus were present in small numbers. A few species of Chrysops and Silvius were also present.--Howell *et al.* (145).

Toxaphene as a 2-percent spray did not protect animals from attack by tabanids or stable flies.--U. S. Bur. Ent. and Plant Quar. (300).

ACARINA

Argasidae

Otobius megnini (Duges), the ear tick

Toxaphene was superior to DDT and comparable with chlordane and BHC for controlling the ear tick.--U. S. Bur. Ent. and Plant Quar. (300).

Ixodidae

Amblyomma americanum (L.), the lone star tick

Toxaphene proved superior to DDT and equal to chlordane, but less effective than BHC against the engorged forms of the lone star tick. Toxaphene sprays at 0.75-percent concentration gave good control of all stages and protection against reinestation for 2 weeks, comparable with that given by DDT and chlordane.--U. S. Bur. Ent. and Plant Quar. (300).

Amblyomma maculatum Koch, the Gulf Coast tick

Good control of all stages resulted when cattle were dipped or sprayed with 0.5 to 0.75 percent of toxaphene and protection against reinestation lasted for 2 to 3 weeks.--U. S. Bur. Ent. and Plant Quar. (300).

Boophilus annulatus (Say), the cattle tick

Extensive tests conducted in South America have shown that sprays containing 0.5 percent of toxaphene are highly effective against all stages of the cattle fever tick present on animals. Complete protection was obtained for 3 weeks and good control for 4 weeks. Protection after 3 weeks was comparable with that obtained 11 to 13 days after treatment with a spray containing 0.5 percent of DDT plus sufficient BHC to give 0.025 percent of the gamma isomer.--U. S. Bur. Ent. and Plant Quar. (300).

Toxaphene applied as a spray destroyed all stages of the fever tick, Boophilus annulatus var. microplus, attached to cattle at the time of treatment and prevented reinestation for 3 to practically 4 weeks, depending somewhat on the breed of cattle involved. The toxaphene emulsion was used in spray tests in concentrations of 0.25, 0.50, and 0.75 percent and in dip tests at 0.53 percent active principle and was applied to four purebred breeds and several grades or mixtures of dairy breeds, including young and very young purebred and grade calves, without any visible injury to the animals or to the personnel handling or applying the emulsion.--Leake (172).

In Australia Cooper Tox (65 percent toxaphene in emulsified form) at strengths of 0.65 percent and 0.55-percent toxaphene concentrations gave practically a 100 percent kill of all ticks on heavily infested cattle. Toxaphene arrests the development of female ticks at once. Within a few hours they detach themselves from the host and die within a relatively short period. No untoward effects on the animals have been noted.--Legg (175).

Dermacentor albipictus (Pack.), the winter tick

Toxaphene was superior to DDT and comparable with chlordane against the winter tick on cattle and horses, when employed either as a spray or as a dust. Good control of all stages was obtained with sprays containing as little as 0.75 percent and this concentration protected against reinestation for about 2 months. A 0.5 percent spray failed to control all the engorged forms, but prevented further reinfestations for 6 to 8 weeks.--U. S. Bur. Ent. and Plant Quar. (300).

Tetranychidae

Paratetranychus citri (McG.), the citrus red mite

Toxaphene proved nontoxic at 1 percent to mites.--Metcalf (198); Metcalf et al. (199).

Paratetranychus pilosus (C. & F.), the European red mite

The application of a 0.125-percent toxaphene spray (as a 25-percent wettable powder) to soybeans permitted only 25 percent of a normal population of mites and eggs to develop.--Wingo and Thomas (324).

On apples in Delaware the red mite populations with DDT alone and with DDT and lead arsenate were moderately large; and with toxaphene and lead arsenate and with toxaphene alone, small to negligible.--Parker et al. (232).

Orchard tests in British Columbia showed toxaphene to be fairly effective against European red mite.--Ross and Armstrong (256).

Tetranychus bimaculatus Harvey, the two-spotted spider mite

Dusts containing 3 to 5 percent of toxaphene were effective in controlling this mite on lima beans on Long Island but were less effective than dusts containing 1 percent of parathion or 10 percent of azobenzene. Toxaphene 25-percent wettable powder, 4 pounds per 100 gallons of water, and toxaphene 50-percent concentrated emulsion at 1:400 also were effective, yielding an increase of clean pods equal to that produced by hexaethyl tetraphosphate 1:800.--Huckett (146).

In the greenhouse, toxaphene had considerable acaricidal value at high rates, e.g. 1 to 4 pounds per 100 gallons. There was little ovicidal action but the residue effectively destroyed the young of two-spotted mite hatching after spraying.--Ross and Armstrong (256).

Same as for Paratetranychus pilosus.--Wingo and Thomas (324).

Tetranychus pacificus McG., the Pacific mite

In 1947 at Yakima, Washington, five applications of a 50-percent water miscible toxaphene at 1:800 controlled the mites and caused no injury to apples.--Newcomer (215, 217); Newcomer and Dean (218); Carlson and Newcomer (37).

Vasates cornutus (Banks), the peach silver mite

In Washington in 1947 toxaphene 1 pint (sic) to 100 gallons of water reduced the average mite population per peach leaf from 395 to 21.5.--Carlson (36).

Trombiculidae

Trombicula (Eutrombicula) splendens Ewing

Trombicula (Eutrombicula) alfreddugesi (Oud.), the common chigger

In tests made near Savannah, Ga., in 1946, toxaphene applied as an emulsion spray at 8, 4, and 2 pounds per acre gave control equal to that of hydroxypentamethylflavan at 4 pounds per acre throughout the 17-day period of observation.--Smith and Gouck (271).

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<u>Eastern tent caterpillar</u>	34	<u>Imported cabbageworm</u>	38
<u>Elasmopalpus lignosellus</u>	39	<u>Imported fire ant</u>	42
<u>Empoasca fabae</u>	22	<u>Japanese beetle</u>	33
<u>Epilachna varivestis</u>	27	<u>Lady beetles</u>	27
<u>Epitrix cucumeris</u>	26	<u>Laphygma frugiperda</u>	37
<u>Epitrix hirtipennis</u>	27	<u>Lasius niger alienus</u> <u>americanus</u>	41
<u>Euproctis terminalis</u>	34	<u>Leaf-footed bug</u>	23
<u>European corn borer</u>	40	<u>Leptinotarsa decemlineata</u>	27
<u>European red mite</u>	52	<u>Leptocoris trivittatus</u>	23
<u>Euschistus servus</u>	25	<u>Leptoglossus phyllopus</u>	23
<u>Eye-spotted bud moth</u>	35	<u>Lesser cornstalk borer</u>	39
<u>Fall armyworm</u>	37	<u>Lone star tick</u>	51
<u>Feltia subterranea</u>	36	<u>Limonius agonus</u>	32
<u>Field cricket</u>	16	<u>Linognathus vituli</u>	17
<u>Fleece worm</u>	42	<u>Liriomyza flaveola</u>	42
<u>Flower thrips</u>	18	<u>Little fire ant</u>	42
<u>Frankliniella fusca</u>	18	<u>Long-nosed cattle louse</u>	17
<u>Frankliniella tritici</u>	18	<u>Lygus hesperus</u>	24
<u>German cockroach</u>	15	<u>Lygus oblineatus</u>	24
<u>Gladiolus thrips</u>	18	<u>Macrosiphum pisi</u>	20
<u>Goat lice</u>	18	<u>Macrosiphum solanifolii</u>	20
<u>Granary weevil</u>	31	<u>Magicicada septendecim</u>	22
<u>Granulate cutworm</u>	36	<u>Malacosoma americana</u>	34
<u>Grape berry moth</u>	35	<u>Meadow spittlebug</u>	21
<u>Grape leaf folder</u>	39	<u>Melanoplus bivittatus</u>	14
<u>Grape mealybug</u>	22	<u>Melanoplus differentialis</u> 13,14,15	
<u>Grapholita molesta</u>	35	<u>Melanoplus femur-rubrum</u> 13,15	
<u>Green chrysanthemum aphid</u>	21	<u>Melanoplus marginatus</u>	15
<u>Greenhouse thrips</u>	18	<u>Melanoplus mexicanus</u>	15
<u>Green June beetle</u>	32	<u>Melanoplus mexicanus</u> <u>devastator</u>	15
<u>Green peach aphid</u>	20	<u>Melanotus spp</u>	32
<u>Gulf Coast tick</u>	51	<u>Melittia cucurbitae</u>	34
<u>Haematopinus adventicius</u>	17	<u>Melophagus ovinus</u>	45
<u>Haematopinus eurysternus</u>	17	<u>Mexican bean beetle</u>	27
<u>Haematopinus quadripertitus</u>	17	<u>Monarthropalus buxi</u>	46
<u>Harlequin bug</u>	25	<u>Murgantia histrionica</u>	25
<u>Hawaiian beet webworm</u>	39	<u>Musca domestica</u>	47
<u>Heliothis armigera</u>	36	<u>Myzus persicae</u>	20
<u>Heliothrips haemorrhoidalis</u>	18	<u>Nezara viridula</u>	25
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<u>Horistonotus uhleri</u>	32	<u>Omnivorous leaf tier</u>	39
<u>Horn fly</u>	48	<u>Onion thrips</u>	19
<u>House fly</u>	47	<u>Otobius megnini</u>	50
<u>Hylastinas obscurrus</u>	33	<u>Orange tortrix</u>	40
<u>Hylemya brassicae</u>	46	<u>Oriental fruit moth</u>	35
<u>Hylemya cilicrura</u>	47		
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